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Sewage Disposal at Amarillo, Texas

General Features of New Plant, Including Preliminary Settling Basins, Aerating Tanks and Sludge Lagoons

By WYNKOOP KIERSTED

Consulting Engineer, Kansas City, Mo.

AMARILLO is located on the High Plains in the Panhandle of Texas at an elevation of about 3,600 ft. above Gulf level on a divide between the South Canadian River and the Pala Duro Creek, a branch of the Brazos River. The ground slopes moderately south and southeastward and rather rapidly north and northeastward into the valley of the South Canadian. For a long time the city was a distributing center of a stock raising country under moderate agricultural development. Its public utilities had kept pace with its growth and were ample for its use until the intensive development of the gas and oil field commenced about 60 miles northeast of the city. The vastness of the oil and gas bearing territory and its great possibilities advertised Amarillo extensively and it became a center for oil and land speculation. A large amount of capital went into oil and gas development, new additions were laid out in the city, and the rapid growth of commercial and industrial enterprises resulted in much building activity and a correspondingly great growth of population. Within a period of two years the population of Amarillo nearly trebled and is now estimated at 45,000 to 50,000 inhabitants. The demand for the extension of the public utilities became correspondingly urgent and even the private utility companies had some difficulty in keeping pace with the demand.

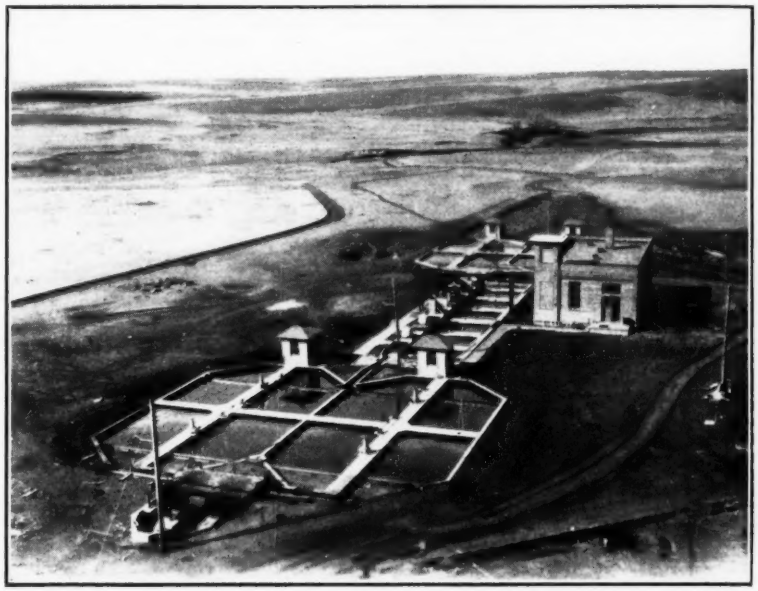


Fig. 1—General View of Settling Basins, Aeration Tank and Blower House

The Old Disposal Plan.—There are no perennial streams in the vicinity of Amarillo, consequently the city had constructed Imhoff tanks for the disposal of its sewage, discharging into one or more irrigating ditches which distributed the sewage over an area of about 120 acres, which was the only portion of the city owned section of land susceptible of irrigation. The land was cropped but the area was too small for successful broad irrigation and considerable offense arose as the result of overtaxed ground. This condition, together with the usual troubles with Imhoff tanks grew steadily worse until the commission, pressed for a remedy for offensive odors, constructed an outfall sewer from the Imhoff tanks 4 miles to a discharge into East Amarillo Creek.

The bed of this creek is dry for the greater portion of each year except for an occasional pool of water sustained by trickling springs and has an average fall of a little over 27 ft. to the mile for approximately 17 miles to its junction with the South Canadian. The constant flow of raw sewage in this ephemeral stream caused nuisances and completely destroyed the value of its water for stock raising purposes, one of the chief industries in that section of the country. With the rapid increase of population these conditions became intolerable and finally the city determined to extend and improve its sewage disposal plant.

Preliminary Investigation and Report.—The author of this paper in making an investigation and report on the situation found that land values were rapidly increasing and that urban growth was continually progressing towards the city owned section of ground on which its disposal plant was located and in fact had passed this section along the adjoining Colorado-to-Gulf Highway. For this and other reasons a new disposal plant was advocated on a site in the valley of East Amarillo Creek four miles below the end of the city outfall sewer. The site selected was particularly advantageous because it is two miles from the nearest residence and the public highway and because here there is a tract of 400 to 600 acres of gently sloping ground in the valley of East Amarillo Creek which could readily be brought under irrigation—a very desirable consideration in an irrigating country.

The author recommended the removal of 80 per cent of suspended matter of the sewage in settling basins and the application of the effluent from the settling basins to land in broad irrigation during the growing season and the chlorination of the effluent from the settling basins and discharge into East Amarillo Creek during the non-growing season. The city commissioners demurred on obligating the city to the operation of a large sewage irrigated farm as a municipal enterprise, but were willing to turn the sewage over to the owner of the property for use in irrigation as a private enterprise. In the end the commission requested the engineer to prepare plans for a trickling filter to receive the settled sewage

with a provision in the specification to receive bids on the trickling filters independently. The author also recommended sludge disposal in lagoons, both because of the isolation of the site and because the available funds were insufficient for the construction of separate concrete digestion tanks.

The lowest bid on the four miles of 18 in. outfall sewer was $52,489, that on the settling basins and lagoons $121,000 and that on about an acre of trickling filter $124,900. The bids on the filter

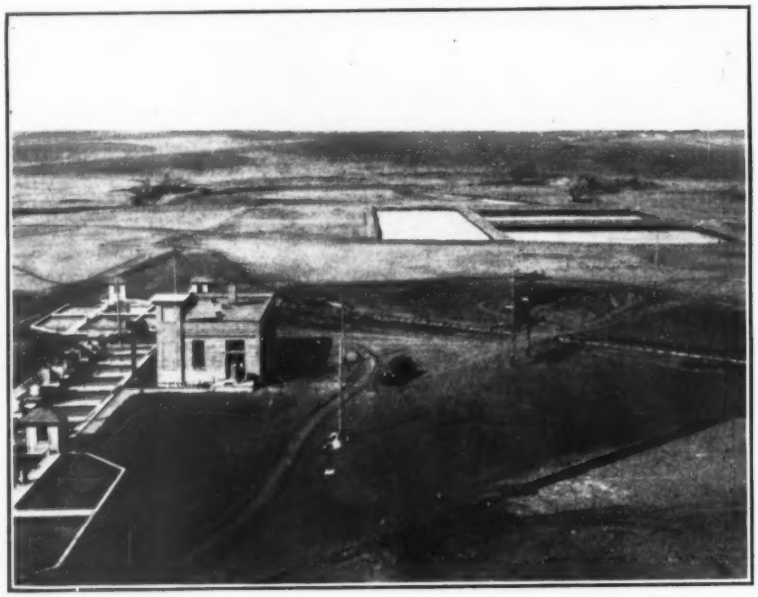


Fig. 2—View of Disposal Works and Lagoons

were finally rejected because of insufficient funds, but contracts were awarded for the outfall sewer and settling basins. The former was completed in the early fall and the latter in the late fall of 1928. A general view of the settling basins, aerating tank and power house is shown on Fig. 1. Figure 2 shows a partial view of the structures and the earth lagoons. A space of ground is reserved between the structures and the lagoons for the construction of trickling filters at some future time. In the foreground of Fig. 1 is the two-compartment screen chamber equipped with inclined bar screens, the necessary valves and an overflow well between the two compartments. The screen chamber connects with the preliminary settling basin by concrete conduit.

The Preliminary Settling Basin.—The preliminary settling basin in the foreground is composed of two compartments, each compartment having two cone-shaped hoppers provided with a vertical rotating shaft with two horizontal arms to which is attached a chain drag. The two compartments are, as a rule, operated in parallel but either may be emptied and the sewage diverted into the other by means of stop planks. The sewage enters each compartment on the longitudinal center line and is given a straight line flow through the basin by means of a suspended wooden baffle with vertical slots the entire depth of the baffle ⅝ in. wide and 6 in. apart. These baffles extend nearly to the bottom of the basins. The sewage is removed by a double-lip weir extending across each compartment of the basin in the position shown in Fig. 1. The position of the weir tends to prevent currents up the wall. The two little structures at the end of the settling basin (see Fig. 1) house the motor and reduction gear which communicates with the line shaft running along the center line of each compartment and which rotates the chain drags. The speed of operation of the vertical shaft is 3 revolutions per hour. The object of using chain drags is to prevent adhesion of the settled solids to the concrete bottom of the hoppers. The sludge is drawn hydraulically through a compound plug valve in each of the hoppers. The larger opening of each plug valve is 12 in. diameter and the small one 3 in. diameter. The 3 in. valve is intended to be partially open all of the time or opened periodically. The 12 in. valve is opened only when desired to drain the basin. The detention period in the preliminary basin is 2 hours at an average rate of sewage flow of 3 m.g.d.

The Aerating Tank.—The sewage from the preliminary basin passes through a flume into an aerating tank 95 ft. long, 19¾ ft. wide and 10 and 20 ft. deep and is given straight line flow by means of a suspended baffle extending nearly to the bottom of the tank with ¾ in. vertical openings spaced 6 in. apart. The aerating tank contains six steeply sloped hoppers 10 ft. deep with a plug valve in the bottom of each hopper connecting with a drain constructed beneath the floor lengthwise of the tank. A 12 in. air-lift pump is installed in each of the six hoppers. Each pump has a capacity to lift 1,240 g.p.m. 4 ft. with air of 3 lb. pressure. The pumps discharge the sewage into a concrete trough constructed on the top of the aerating tank and shown on the left side of the tank in Fig. 1. The sewage thus pumped into the tank flows back to the inlet. The six pumps operating continuously deliver sewage into the trough at the rate of a little over 10½ m.g.d. Thus the sewage is withdrawn from the tank, aerated and returned to the inlet and nearly four times during the one hour detention period when the flow from the preliminary basin is at a rate of 3 m.g.d. The purpose of the aeration is to remove the gases from the sewage and to break up insofar as possible the colloidal condition of the suspended sediment. Little oxidation of dissolved organic matter is expected. The sewage is weired into a trough at the outlet end of the tank, thence passing into the secondary settling basin which is structurally a duplicate of the preliminary basin. Thus the sewage is detained in the settling basins and aerating tank 5 hours at the stated normal rate of flow.

The Sludge Lagoons.—The sludge lagoons, covering an area of between 3 and 4 acres, were constructed of earth embankments in three divisions of approximately equal capacity of an average depth of about 11 ft. It was designed to use one at a time until fully charged with sludge, then deliver the sludge to the second lagoon while that in the first was digesting and so on until the use of the third became necessary when the sludge in the first should be in a condition for removal. The overflow from the lagoons passes onto a 5-acre leveled area inclosed by a low embankment where it is expected to disappear by evaporation and by seepage through the ground into the adjoining stream. Since the evaporation in the Panhandle district of Texas approximates 5 ft. per year, no difficulty is expected in disposing of this overflow by evaporation. Some odor is expected from the lagoons, but because of their isolation and the prevailing southerly winds no offense is expected to dwellers along the highway two miles to the westward.

The Blower Units.—The building adjacent to the aerating tank contains three Connersville blowers, each unit having a capacity to compress 700 cu. ft. of free air per minute to a pressure of 3 pounds and to deliver it to the air-lift pumps. These motor driven blowers of the rotary displacement type operate at 575 r.p.m. The air for the blowers enters the tower at one corner of the building, passes downward through air filters, thence into a duct beneath the floor of the blower room to the blowers and is delivered to the pumps through a 12 in. pipe line. In the building are also installed a Wallace & Tiernan chlorinator and a dry feed machine for feeding either alum or copperas either where the sewage passes into the aerat-

ing tank or into the secondary settling basin.

The plant has now been in operation about a year. An average of two weeks', analyses of the sewage passing through the outfall sewer prior to the construction of the new sewage disposal works, showed the dissolved and suspended solids to be 1,570 p.p.m., dissolved solids 1,120 p.p.m., suspended solids 450 p.p.m., hydrogen-ion concentration 6.8. The total dissolved solids in the city water supply was 363 p.p.m. This unusually strong sewage for a city like Amarillo is due in part at least to the absence of ground water infiltration and to the scarcity of city public water supply at the time the tests were made. Provision was made for prechlorination of the sewage at the head of the outfall sewer near the city limits in order to delay septic action at any time the sewage was found to be septic as it entered the disposal works. So far as we know there has been no occasion to prechlorinate because the time of passage through the 8 miles of outfall sewer, half of which is laid at an average gradient of .66 per cent and the other half at an average gradient of .25 per cent, has not been long enough to start any pronounced septic action.

Operating Results.—During the time the disposal plant was under construction about a mile of irrigation ditch was constructed; the owner of the adjacent property, extending for miles in every direction, having arranged to irrigate some at least of his land susceptible of irrigation. After the disposal plant had been in operation several weeks an efficiency test was made of it in December, 1928. For the first five days of this test the sewage passed through the old Imhoff tanks near the city limits. It entered these tanks with 520 p.p.m. of suspended matter but the effluent still contained 205 p.p.m. This effluent then was passed through the new disposal works where the suspended matter was reduced from 205 p.p.m. to 45.5 p.p.m., which represents nearly 78 per cent removal of the suspended solids in the Imhoff tank effluent. The Imhoff tanks were then cut out and the raw sewage, still containing 520 p.p.m., was passed directly through the new disposal plant in which the suspended solids were reduced to 30 p.p.m., representing an average removal during the five days' time of the test of 94.2 per cent of suspended solids. The average condition of the effluent from the preliminary basin during the test was 60 p.p.m. of suspended matter, or about 88.46 per cent removal. The remaining 30 p.p.m. removed in the secondary settling basin after aeration is equal to 50 per cent of removal of the remnant from the preliminary basin or little over 5.7 per cent of the total suspended solids. No records of summer time operation are now available. The records further show an average removal of suspended matter up to Feb. 5, 1929, of a little over 89 per cent and a reduction of the biological oxygen demand of 63.7 per cent on the basis of the 5-day test.

The plant is capable of removing at least 90 per cent of the suspended matter under careful supervision. We are informed that the city commission entered into contract with the owner of the property adjoining and including East Amarillo Creek to remove 90 per cent of the suspended matter in the sewage delivered to the disposal works. With this 90 per cent removal the sewage is in excellent condition to be applied to land in broad irrigation without becoming offensive and in the same condition it is thought it could be applied to a trickling filter with 6 ft. depth of stone of about half the area generally allowed for the purification of the effluent from Imhoff tanks. This distinctly represents a probable economy of the usual plant investment since a filter is more expensive than a settling basin.

Contract for Well Drilling

Well drilling involves many uncertainties, and even without a guaranty as to water the driller assumes much financial hazard. A form of contract that gives a driller an adequate reward for skillful performance without requiring him to assume undue hazards is given by Oscar E. Meinzer in U. S. Geological Survey Water Supply Paper 597-C, "Problems of the Soft-Water Supply of the Dakota Sandstone." We quote as follows:

If the water is obtained from hard rocks, the driller may have performed his entire duty when he has sunk the hole to the required depth. If, however, the water occurs in beds of sand or other incoherent material the driller's work is not complete when he has made the hole, but only when he has, so far as possible, developed or finished the well in such a manner that it will yield a water supply without inflow of sand, silt, or clay and will remain in good condition for a period of years. The process of developing or finishing the well requires quite as much skill as the process of making the hole, and, if properly done, it may consume much time. A reliable driller will not leave a well in an unfinished condition or in a condition that will cause trouble in the future. However, if he is paid only at a certain rate per foot for making the hole, he can hardly afford to spend much time in developing the well, and if he does so he is at a great disadvantage with his less scrupulous competitors. In localities where wells end in sand it is therefore desirable to devise a form of contract that will give the driller adequate reward for skillful work in finishing a well without requiring him to assume undue hazards. Such a form of contract will also be advantageous to the persons for whom the wells are drilled, for it will tend to give them the services of skillful drillers on competitive terms.

The problem of a proper form of contract confronted the United States Office of Indian Affairs when it asked for bids for drilling the well at the asylum at Canton. The following specifications are essentially as they were prepared by the Geological Survey with a view to meeting the conditions outlined above:

Specifications for one well to be sunk at the Asylum for Insane Indians, Canton, S. D., into the sandrock that bears soft water:

The bidder shall furnish all equipment and labor necessary properly to construct and finish the well and shall furnish the casing and strainer and any other material or element that may be required to construct the well in a workmanlike manner. He shall case the well from top to bottom with 8-in. standard casting or pipe. [Diameter was later specified to be 6 in.] He shall so construct the well at the bottom as to shut off and seal the well from any water entering from above the soft-water sandrock. He shall also construct the well in the soft-water sandrock at the bottom in such a manner that it will furnish at least 15,000 gal. of water in 24 hours without interference or trouble from sand or any other cause during a pumping test of at least two days' duration. He shall commence sinking the well within a reasonable period after the approval of his contract, shall continue operations without any unnecessary delay until the well is finished, and shall complete the well by Nov. 1, 1926. When the well is completed with the above-mentioned guaranty as to yield and freedom from interference by sand or from other trouble, he shall receive full payment at the rate of $—— per foot of well drilled.

It is understood that the well shall be drilled to a maximum depth of 350 ft., if necessary, unless the hard Sioux quartzite, or "Sioux Falls granite," is struck before that depth is reached. It is further understood that in case it is impossible, on account of the absence or unsatisfactory character of the sandrock, to fulfill the above-mentioned guaranty, the contractor shall be paid at the rate of one-half of the above-mentioned price per foot drilled.

Because of the guaranty of "15,000 gal. in 24 hours without interference or trouble from sand or any other cause during a pumping test of at least two days' duration," the contract was attractive only to skillful drillers, and it gave the successful bidder a strong inducement and a proper reward for doing his best work. On the other hand, by specifying half price if the driller should not succeed in fulfilling the guaranty, he was protected from assuming an excessive hazard. In general, government contracts for drilling wells have been very exacting in their requirements, and this has resulted in discouraging bidders and in making the bids excessively high. It is believed that an equitable and reasonable contract is to the interest of the government in procuring the services of skillful and reliable drillers at moderate prices.

The advantages of this form of contract could, of course, have been obtained with specifications of other kinds. For example, the driller might be paid a certain price per foot for making the hole and an additional sum for fulfilling the guaranty. This would not be very different in effect from the actual specifications but would have the disadvantage of requiring a more complicated bid and of being a more radical departure in form from the usual contracts.

The successful bidder for the contract for the asylum well was Mr. E. C. Archibald, Council Bluffs, Ia., whose bid of $5 a foot was the lowest submitted.

Developments in 1929 in the Chemical Treatment and Filtration of Water

Taste Elimination—Prevention of Corrosion—Water Softening—New Filtration Plants—Coagulation —Laboratory Work—Bacterial Quality—Design and Equipment—Filter Clogging —The Surface Wash—Aeration and Chlorination

By JOHN R. BAYLIS
Associate Editor, Water Works and Sewerage

THE articles on water purification which have appeared in the various publications within the past 12 months indicate we are moving forward in this field at a very rapid rate. They cover practically every phase of water treatment, and it is evident that our scientists in the water purification field are keeping pace with those in other lines of work. Certainly there is no period in history in which the work has been on so high a plane or the achievements greater. The American Water Works Association with its water purification division and 17 local sections, the New England Water Works Association, the American Chemical Society, the American Society of Civil Engineers, the various state organizations which hold annual meetings, such as water works schools and conferences, and other technical societies, all have programs at their various meetings with one to a number of papers on water treatment and filtration. In addition to the proceedings and journals of these organizations, there are several other publications giving a great deal of space to water purification. Surely such an abundance of literature records much that represents improvement in the treatment of our drinking water. Also it is creating an interest in the subject far greater than our expectation of only a decade ago.

It is not one or two achievements that makes the past year noteworthy in accomplishments, but improvements along many lines. The young and the old, the newcomer and the veteran in water purification have put their shoulders to the wheel and we are moving forward in a manner that makes us feel proud. The most difficult problems are being attacked by men well trained in their work, and some of the problems that have baffled us heretofore are being solved. Each year brings about a greater sense of responsibility on the part of the chemist and the engineer to produce safer and more palatable water.

Water Borne Diseases Have Been Reduced to a Minimum.—The death rate of water borne diseases is diminishing almost to the vanishing point. Seventy-four cities with a population of 26,737,000 people reported 1,796 deaths from typhoid fever in 1918. These same cities with a population of 33,116,000 in 1928, reported only 627 deaths from the same cause. This is a reduction from 6.72 per 100,000 in 1918 to 1.89 in 1928, or over 70 per cent. We should like to think that only a few of the cases of typhoid fever in 1918 were contracted from water, for most of the plants had very good treatment for the removal of bacteria at that time. The record indicates, however, that there has been no let-up in the efforts to have the water entirely free from disease producing bacteria, even though some of the supplies before treatment have become more highly polluted. Before a supply becomes contaminated to the point where there is doubt as to the safety of the water, and a less polluted supply is not available at a reasonable cost, improvements are made in the methods of treatment so as to take care of the increased pollution.

Taste Elimination.—More and more do we realize that the public wants water of the highest quality and water free from objectionable tastes. Perhaps the greatest achievement in the water purification field for some time has been the perfection of treatments to remove or to prevent objectionable tastes. This, of course, is not a development originating within the past 12 months, but much has been contributed to our knowledge of taste elimination during that time. Many water supplies at times are subject to disagreeable tastes that cannot be removed by coagulation and filtration. In some instances filtration has been discredited in the eyes of the public because perfectly palatable water is not being supplied all the time.

Efforts in taste elimination have been along several lines. Probably the most notable contribution to taste elimination within the past few years has been made by Howard at Toronto. An excess of chlorine is added, and the water is later dechlorinated with sulfur dioxide. McAmis at Greeneville, Tenn., was the first to use ammonia in this country on a plant scale for taste elimination. Spalding at Springfield, Ill., and Ellms at Cleveland, O., report good results with ammonia. Potassium permanganate is being added to several water supplies with apparently very good results. Caird at Rochester, N. Y., was the first to use this material on a plant scale. Harrison at Bay City, Mich., finds potassium permanganate effective in preventing tastes, but does not get very good results with ammonia. Recently it has been found that activated carbon is very effective in removing taste-producing compounds from water.

Ammonia apparently prevents the formation of the chloro compounds that produce disagreeable tastes. Potassium permanganate and superchlorination oxidize certain of the taste-producing compounds, whereas activated carbon absorbs the compounds. With a combination of superchlorination and activated carbon, which also dechlorinates the water, practically all objectionable tastes that are likely to occur in a water supply may be removed. Superchlorination, preammoniation, and the use of potassium permanganate have the advantage that very little plant investment is necessary, but such treatments require close supervision. Reports from various points where these treatments have been tried indicate they are not successful in the complete elimination of all tastes, but certainly they can produce a marked improvement in the taste of the water in many localities.

No one so far has reported a taste that cannot be removed by superchlorination and then passing the water through a bed of active carbon. The use of the active carbon also obviates the necessity for close chlorine control. Such excellent results should insure extensive use of this process. Due to the fact that the carbon is expensive, and that provision has to be made for passing the water through a bed of the material, the initial cost is high. The operating cost is low, and when every thing is taken into consideration the cost compares very favorably with other treatments. The fact that this treatment covers a wider range of taste-producing compounds that may be removed from water than any other treatment, and is almost fool-proof in operation, should make it particularly attractive to small cities.

If progress in water purification had been confined to taste elimination, the past year would still be noteworthy for its accomplishments. It has been demonstrated conclusively that the more common taste-producing compounds, such as are produced by decaying vegetation, micro-organisms and phenols,

may be completely removed by one or more of the several methods mentioned. No city willing to make the small expenditure need now tolerate disagreeable tastes, except perhaps in very unusual cases. It appears that most any water may be made perfectly palatable all the time for an expenditure less than $1.50 per million gallons.

Prevention of Corrosion.—Treatment of water to prevent corrosion and red water is being extended gradually to the corrosive waters. It has been about 10 years since the treatment was started at Baltimore, and every year sees a few more cities added to the list of those treating water to reduce corrosion. If the writer is correctly informed, New York City has abandoned its work on corrosion prevention for the present. This, however, will not discourage others who are anxious to deliver water to the consumer of the highest quality. In fact lime was not tried in New York on a large scale, and those who are familiar with corrosion prevention would not expect the sodium compounds to be of much aid on so soft a water. The advantages and economy of non-corrosive water are demonstrated quite conclusively in practically all places where it is given a fair trial, and it is likely only a matter of time until nearly all corrosive waters will be treated. Where various treatments for corrosion prevention, such as lime, soda ash, sodium hydroxide and sodium silicate, have been compared on a plant scale, lime shows its superiority over other treatments for very soft waters. For moderately hard to hard waters it probably makes little difference which material is used, except that lime is cheaper.

Water Softening.—More water softening plants are being constructed every year, and some of the existing plants are making their treatment processes still more effective. Where magnesia is present in quantities greater than 10 to 15 parts per million of Mg there is an increased use of what is commonly called the excess lime treatment. Lime is added to the water to produce a pH of 10.5 to 10.8 so as to precipitate most of the magnesia as magnesium hydroxide. This treatment leaves the water with 25 to 50 parts per million of caustic alkalinity, composed largely of calcium hydroxide. The caustic alkalinity has to be converted to the carbonate by the addition of carbon dioxide.

The greatest precipitation of calcium carbonate that may be effected within the few hours it takes the water to pass the treatment plant occurs at a pH of 9.5 to 10.0. This is high enough to give the water a taste characteristic of lime softened water. The use of carbon dioxide in softening plants is becoming more extensive, and the writer is of the opinion that practically all municipal softening plants using lime or soda will eventually recarbonate the water. The water should be left just saturated with calcium carbonate, or with only 4 to 5 parts per million supersaturation. In softening processes where calcium carbonate is precipitated, considerable supersaturation of calcium carbonate has to be produced for precipitation to take place. Usually 20 to 40 parts per million supersaturation of this compound is left in the water and it will incrust the sand grains in the filter beds and all surfaces with which the water comes in contact unless the water is given additional treatment. The addition of carbon dioxide is being found to be the most desirable additional treatment.

Zeolite softening is being extended rapidly to industrial plants where it is economy to have very soft water. There are now four or five municipalities using zeolite softeners. For laundries and boiler plants it is becoming the custom to use zeolite softeners where the hardness is in excess of 20 to 30 parts per million.

Taste elimination, prevention of corrosion, and water softening, constitute efforts to take a water of inferior quality after filtration and produce water of the highest quality. Surely our dream of the perfect water for every city is much nearer a realization than was believed to be possible only a few years ago. In many instances the water has been changed so greatly in characteristics due to the treatment that it should be regarded more as a manufactured commodity than one of Nature's products.

New Construction.—Construction of new filtration plants has progressed at about the usual rate. Twenty or more new municipal plants have been put into operation within the past year, the new Howard Bend plant at St. Louis probably being the largest. This plant is probably the most elaborately equipped filtration plant ever constructed. The beautiful exteriors of the new plants at St. Louis and Baltimore, and the interiors of the newer plants at Cleveland, Washington and St. Louis, set a standard in construction that will be followed by many plants in the future. In fact the influence is already noted in the imposing structures recently built in some of the smaller cities. Beautiful structures may not be necessary for the production of high quality water, but they are in keeping with the present tendency to make every thing in connection with water supply attractive.

Coagulation.—There has been only one major development in the coagulation of water within the past two or three years. Mohlman and Palmer found that chlorine added to a solution of ferrous sulfate produces ferric sulfate and ferric chloride, and that these compounds will produce coagulation when the pH is very much lower than is essential for ferrous sulfate to produce coagulation. Their work was on sewage, but it did not take the water chemist long to start experimenting with chlorinated iron to see if it had possibilities in water treatment. Good precipitation has been found to take place between pH of 5.0 and 11.0, making its range very much broader than that of aluminum sulfate. The work of Hedgepeth at Elizabeth City, N. C., Decker and Menke at Chicasaw, Ala., and the writer at Chicago, indicates that chlorinated iron is a better coagulant than aluminum sulfate for many waters. Ferric chloride appears to be even more effective than chlorinated iron, but due to its price being considerably higher than that of ferrous sulfate the cost of coagulating water with this material appears to be higher. It seems probable that the ferric compounds will give aluminum sulfate serious competition and probably will result in lessening the cost of coagulating water. The past year has contributed much to our knowledge of the use of chlorinated ferrous sulfate in water treatment.

Laboratory Work.—The hydrogen-ion test is now fairly well understood by water chemists and many are making use of the test in their treatment process. A knowledge of the hydrogen-ion concentration of the water is almost an essential for the most efficient application of chemicals to water, except where very small quantities of aluminum sulfate are added to hard or moderately hard waters.

The use of instruments to measure the turbidity of filtered water is being extended rapidly. The best operated filtration plants are striving to produce filtered water with turbidity not greater than 0.2. In fact we see several other pieces of new equipment in the leading water laboratories in addition to the sensitive turbidimeter, such as laboratory filters, stirring machines, and other experimental apparatus. More attention is being given to the laboratory in new filtration plant designs than heretofore. The new laboratory in the Howard Bend plant at St. Louis, perhaps the most complete of any filtration plant laboratory in the world, makes us feel that the value of the technical workers in such plants has not been underestimated by the designer.

Bacterial Quality.—The present bacterial standard allows an average of not more than 1 B. coli per 100 cc. of water. The better operated plants have set their aim much higher, and many plants are averaging not more than 1 B. coli per 1,000 cc. Until this latter figure is attained, the filter operator is not justified in reducing the treatment to save operating costs. In fact we may look for 1 B. coli per 1,000 cc. being the standard some day. The chemical advantage of superchlorinating polluted water is becoming so apparent that it will be this and not bacteria that will determine the amount of chlorine to be used in many plants. With a residual chlorine requirement of from 0.3 to 0.5 parts per million two or three hours after application, the

bacterial test becomes almost useless. The quality is insured by the residual chlorine test, and the safety of the water is known immediately and not several days afterward, as is the case when we have to wait for the bacterial results.

Design and Equipment.—In plant design and equipment there have been no recent developments of major importance. Most of the new plants are installing dry feed machines for applying the chemicals to the water, but this is more a matter of choice than any superiority of one method of applying chemicals over another. Better means of handling and storing chemicals are being provided. Air conveyors appear to be on the increase for transporting chemicals in the larger plants. Softening plants and other plants handling highly turbid waters are making greater use of continuous sludge removing devices in the settling basins. The value of a fairly long mixing period has been demonstrated in most waters, and most of the newer plants are being equipped with mixing basins having ample mixing time. Mechanical mixing appears to be on the increase.

There has been no radical change in the design of filter beds. Some of the newer designs have the sand beds located lower so that there will be little or no negative head on the beds. This lessens air-binding troubles. Twenty-four to 27 in. of sand is usually specified, and there is a tendency to use slightly coarser sand than a few years ago. It has been found that sand of 0.5 mm. to 0.6 mm. for the 10 per cent size usually gives good filtration results and does not clog so quickly as finer sand. There still exists a variety of opinions as to the best type of underdrains for filter bottoms. With all the efforts that have been made to improve the filter bottom it is doubtful if anything so far tried has much superiority over perforated pipe laterals. The manufacturers of filter rate controllers and other devices for filtration plants have not come out with new models so frequently as manufacturers of automobiles and radios, but every year sees something new, or something that has been improved.

Solving Filter Clogging Troubles.—There has been a more determined effort to solve filter clogging troubles than heretofore. Hulbert and Herring at Detroit believe that a high rate of wash to give a sand expansion of nearly 50 per cent during washing will keep the beds in good condition. It is their opinion that an expansion of 40 to 45 per cent is the minimum for satisfactory results. It is hoped that so simple a treatment will produce the desired results, but the writer is of the opinion that it will not for many waters. It is true that many filter operators give very little attention to the wash rate actually being used, and it may be found that many plants are not using the 24-in. vertical rise for which the plant was designed, if a check-up were made. If sand expansion can be measured conveniently enough to insure its regular use, it will result in improved conditions at many plants. Is it not imposing a task on the operator that he very likely will not perform with a degree of regularity sufficient for good results? The writer is of the opinion that mechanical rakes or the surface wash is the only real solution to much of our filter clogging trouble. Mechanical rakes are not practical except in small circular filters, but the surface wash may be used on any size and shape bed.

The Surface Wash.—The surface wash is composed of pipe laterals located just above the sand surface and spaced about 18 to 24 in. apart with holes about 3/16 in. in diameter about 12 in. apart on both sides of the laterals. The holes are pointed downward at an angle of about 30 deg. to the horizontal. With a pressure of 20 to 30 lb. on the jets considerable agitation of the sand in the path of the jets is produced. The surface wash is used at the time the filter is washed from underneath. The force of the jets extends some distance from the pipes, but it is not great enough to disturb the gravel. Neither does it disturb the water above the suspended sand any more than it is disturbed by the usual wash. The force of the jets greatly agitates the sand and break up all mud balls and clogged masses of sand. The application of wash water underneath the bed to produce 18 to 20 in. vertical rise per minute and 4 to 6 in. through the surface wash gives an agitation of the sand much greater than can be produced by applying water underneath, regardless of how great the rise per minute may be. The success of the surface wash where it has been tried should insure its use in many filtration plants in the future.

Aeration.—A few of the recent filter plant installations provide for aeration. This is helpful in removing dissolved gases such as carbon dioxide, and in reducing certain of the taste and odor producing compounds. Aeration also is used for increasing the dissolved oxygen content of water low in dissolved oxygen. Recent developments in taste and odor removal indicate that aeration will not be extended very much for this purpose.

Chlorination.—Chlorine is being used in such a variety of ways in water treatment that no one can predict what the future will bring forth. The chief recent developments involving the use of chlorine other than for sterilization have been mentioned already. The addition of chlorine to the water in advance of filtration is on the increase, and the writer is of the opinion that prechlorination is an advantage for many waters.

It seems that one of the most important developments in water purificatio within the past 10 to 15 years is th type of men being attracted to thi field. Ambitious, and well trained i the fundamentals of water treatment, we may expect much from such workers in the future.

Airplane Surveys Give Base for Plane-Table Work

In contributing to a discussion of the American Society of Civil Engineers on the application of airplane surveys to topographic mapping, W. N. Brown gave the following outline indicating the process followed:

"First, a controlled mosaic is made on plane-table sheets 24x30 in. in size. In order to get an accurate control mosaic, there must be located over the area a number of points that show on the photograph. Coordinate positions of these points must be computed and the points platted on the plane-table sheets. The photographs are then brought to proper scale in agreement with these platted points, and made into a photographic base map, upon which the coordinate lines are drawn. The plane-table sheet is then ready for the field where the contours are located by stadia vertical angle methods.

"The topographer, starting from a known control point, carries a continuous traverse for position and elevation, at the same time checking the accuracy of his photographic base map. This map also serves as a check against mis-read or mis-platted rods. If he reads a rod at a stream fork or fence line, or other definite feature, and it does not agree in position with that shown on the base map, he checks his reading and either discovers it to be his error or picks up an error in his base map. If the photographic base map has been properly controlled and made, the error will usually prove to be his own.

"The economy of field operation is apparent. He does not have to read rod for such details as stream and road location, buildings or other objects, but only takes rod readings necessary for controlling the contour location and checking the base map where he thinks it advisable. The field work is reduced at least 50 per cent. The resulting map has better expression of contours and details of stream than could be obtained for the same money by any other method.

"The error of scaling the distance between any two points located at widely separated distances on the map should not exceed 1 part in 5,000."

Water Purification in North Carolina.—One hundred per cent of the filtered surface supplies of North Carolina are chlorinated. Seventy-four of the 78 filtered supplies are scientifically operated, being either under chemical or chemical and bacteriological control.

Records and Tests for Sewage Treatment Plants

Methods for Determining Efficiency of Grit Chamber and of Solids Removal; Condition of Sludge, and Daily Flow of Sewage

By HERBERT BOSCH

Assistant Public Health Engineer, State Board of Health of Missouri

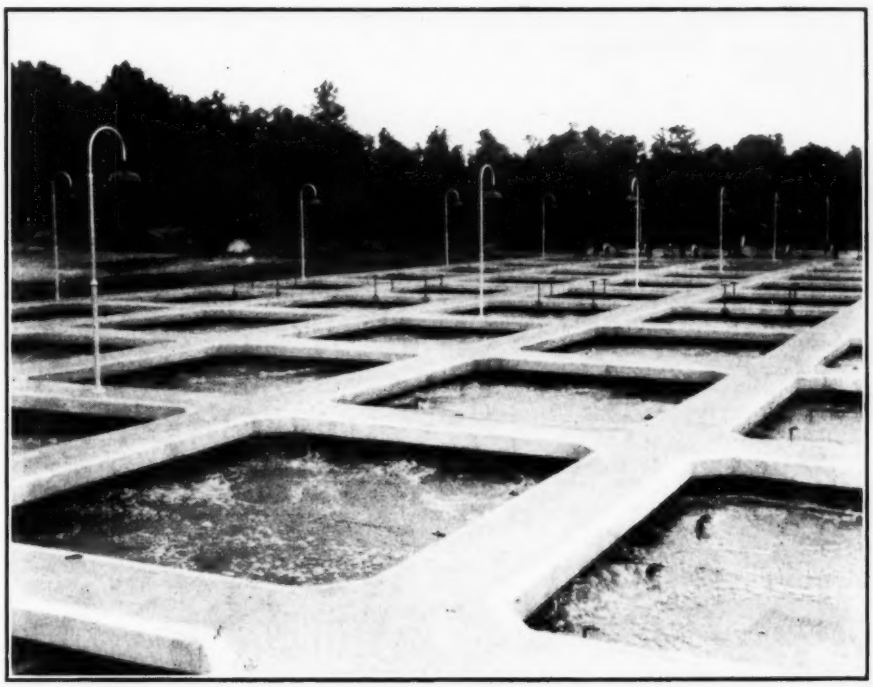
SEWAGE treatment plants are notably very far behind their companion municipal plants, the water works, in the matter of keeping of records and making of tests. The great improvement in the water works field, however, has not come about all at once but has rather been the result of years of constant work. It is not expected that sewage plants will change immediately from their present slipshod operation to a system of efficient control, but there should be at least a gradual trend in that direction. Much depends on the operator. Operation of a sewage treatment plant is a part of the municipal obligation, and the city must employ an operator who is capable of giving the plant intelligent operation.

Why Tests Should Be Made.—There are several reasons why simple tests should be made and records kept at sewage disposal plants. Needless to say, tests will give the operator an index of how efficiently his plant is operating. Despite a rather common opinion to the contrary, there is no type of sewage plant which will keep itself running effectively without attention. Routine tests give an advance warning of conditions which might impair the efficiency of a plant as well as evidence that the plant is running smoothly. Records of efficient operation are of value in court in event of suits against the city by landowners downstream from the plant for damages alleged to have been done by sewage in the stream. It is hardly necessary to point out that such suits are likely to occur at any time.

A second reason for making of tests and keeping of records lies in the fact that almost every town now having a sewage plant will sooner or later have to either extend or rebuild its present treatment plant. At such a time records of plant performance, and of the characteristics of the local sewage will be of inestimable value in making the addition to the old plant or in designing a new plant. There are very little data available now on the properties of sewage in this state and on the operating characteristics of various types of plants, and a designing engineer must depend on data from other localities where the conditions are not the same as they are in this state.

The first simple test which should be made is the temperature of the raw sewage, of the sludge and of the air. Temperature has a great influence on the digestion period necessary. Imhoff states that it takes twice as long to digest sludge at 50° F. as it does at 60° F.

Determining Efficiency of Grit Chamber.—Most plants, especially those which have combined sewers, are equipped with grit chambers, which should be designed to separate the inorganic solids from the influent sewage, but should not trap organic matter. To determine the efficiency of the grit chamber a sample of the grit is dried and weighed and then the volatile organic matter is burned off. The loss in weight represents the volatile organic matter. If it is high, say over 50 per cent, the grit chamber is removing too much organic matter, which tends to become septic and produce objectionable odors.



Aeration Tanks at Sugar Creek Sewage Disposal Plant, Charlotte, N. C.

How to Determine Efficiency of Solid Removal.—Most of the sewage treatment plants in this state utilize Imhoff tanks, but there are also a few separate sludge digestion plants in operation. In either one of these types of plants, some knowledge should be had of how efficiently the settling tanks are removing solids from the sewage. The simplest method of doing this is by means of Imhoff cones. These are glass cones about 15 in. high which are calibrated to hold one liter and are graduated at the tip. A liter of sample is placed in the cone and allowed to settle for two hours. At that time the solids which have settled in the tip of the cone are read off, the results being expressed in cubic centimeters per liter. If this test is made on the raw and settled sewage, the percentage of solids removed is very readily calculated. The only precaution necessary in making this test is to tap the cones gently after about 15 minutes of settling in order to insure that the solids do not adhere to the sides.

In activated sludge plants where sludge is being constantly returned to the primary settling tank, settleable solids are best determined by means of a cylinder rather than a cone. The contents of the cylinder are allowed to stand for one hour, after which it is read, the results again being expressed in cubic centimeters per liter.

If an analytical balance is available, the suspended matter by weight should be determined by the Gooch Crucible method. A Gooch crucible is a crucible provided with a perforated bottom which is covered with a thin asbestos mat. By the aid of suction, a definite volume of sewage is filtered through the crucible after which the crucible is

dried and the increase in weight is noted. From this the suspended matter in parts per million is easily calculated. The per cent removal of solids in the settling tank may be computed if this test is made on the sewage influent and effluent to the tank.

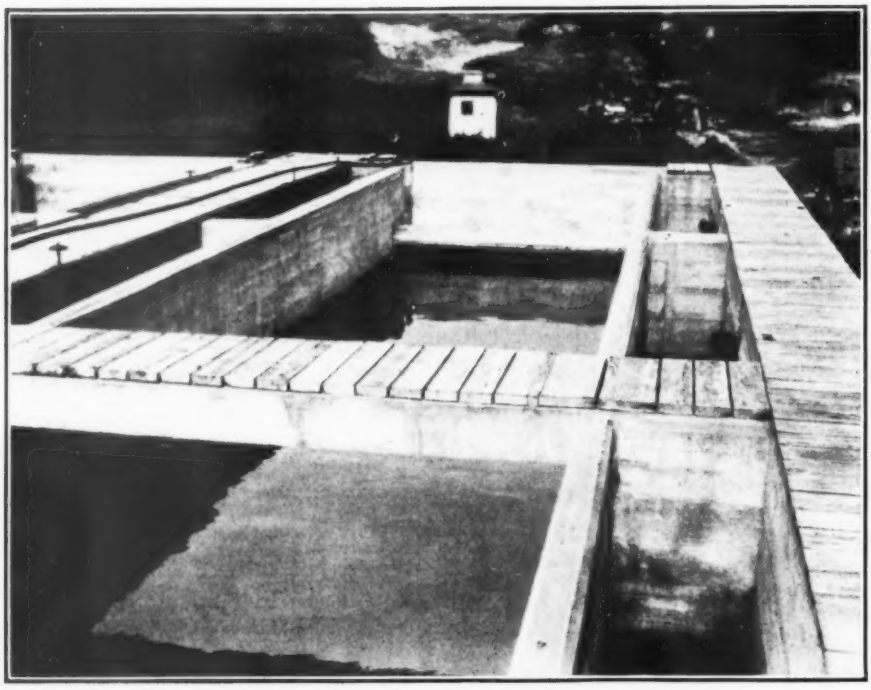
Data on sludge withdrawals should be kept. The data should include the date of withdrawal; the amount of sludge drawn; the quantity of dry sludge which is yielded and the quality of the sludge, and the moisture content of the sludge. The latter is determined by weighing a quantity of the wet sludge and then drying it. The loss of weight represents the moisture content.

Testing Condition of Sludge.—The digestion of sludge is affected by its alkalinity or acidity during digestion. Sludge digestion should take place in an alkaline condition. Some knowledge of the condition of the sludge can be secured by testing it with litmus paper, litmus being blue in an alkaline medium and red in an acidic medium. However a much better knowledge is secured by means of Hydrogen Ion Determinations. The results of this test are expressed as pH numbers. Neutrality is indicated by a pH of 7.0, anything less than a pH of 7.0 is acid and anything greater than 7.0 is alkaline. Sludge digestion is most favorable with a pH of from 7.2 to 7.4 and if the pH falls below 7.0, foaming is apt to occur. Hydrogen ion determinations are made coloremetrically. Dyes are used as indicators and comparison is made with standards of a definite pH. Complete outfits are available which make this determination very simple.

Test of Efficiency of Treatment Plant.—Probably the most reliable test of a treatment plant's efficiency is the test for the biochemical oxygen demand of the sewage. This determination measures the oxygen required to stabilize a sewage. Unfortunately, this determination is rather difficult to make, but an intelligent operator can learn the technique. If it can be made on the raw sewage and on the effluent from the plant, the decrease in the B.O.D. can be easily computed, and from this a knowledge of the efficiency of the plant and the suitability of the sewage for discharge into a watercourse is obtained.

A simpler test for judging the quality of the effluent from a plant which has complete treatment is the methylene blue stability test. This test is made by adding methylene blue indicator to a bottle containing the effluent from the plant and noting the number of days necessary for the solution to decolorize when the temperature is maintained at 70° F. or 20° C. The following table gives the relative stability in terms of the days necessary for the solution to decolorize.

Time required to decolorization at 20° C. (Days)	Relative Stability (Per Cent)
0.5	11
1.0	21
1.5	30
2.0	37
2.5	44
3.0	50
4.0	60
5.0	68
6.0	75
7.0	80
8.0	84
9.0	87
10.0	90
11.0	92
12.0	94
13.0	95
14.0	96
16.0	97
18.0	98
20.0	99



View of Portion of Sewage Disposal Plant of Teaneck, N. J.

It has been found that this test is of little value in judging the quality of the effluent from an Imhoff tank unless secondary treatment is employed. Precaution should be observed not to add an excess of the methylene blue indicator since an excess of the indicator prevents the decolorization of the solution in the time at which it would normally occur and this gives fictitious results.

Determining Daily Flow of Sewage.—Another record which should be kept at the plant is the daily flow of sewage. It is hardly practical to install Venturi meters at the smaller plants for measuring the flow. However, an approximation can be obtained by several methods. One of these is by means of a stroke counter attached to the dosing chamber. From the capacity of the dosing chamber and the number of discharges, an approximation of the sewage flow can be obtained. Another way of roughly approximating sewage flow is by measuring the depth of sewage in a sewer and computing the flow from this and the size and grade of the pipe.

Of course, a convenient record of the test should be made. The value of the tests is increased greatly if permanent records, always available for reference, are kept. Standard forms for keeping of records will be furnished by the State Board of Health.

No attempt has been made to describe the determinations for the ammonias, nitrates, nitrites, chlorides and fats. These tests are of course of value but require a trained chemist to make them. It is believed that the tests outlined above are of greater value as routine determinations for the plant operator. The State Board of Health will be glad to render all possible aid, in the way of instructing operators in the making of tests, to plants which buy the necessary equipment.

Acknowledgment.—The foregoing is a paper presented at the 5th annual meeting of Missouri Water and Sewage Conference held at Chillicothe, Mo., Oct. 21-23.

New York City to Have Municipal Sanitation Commission.—The voters of New York City at the election last month approved a proposition for the establishment of a municipal sanitation commission. The plan provides for the consolidation of several existing city agencies under one head with broad powers over sewage disposal, garbage disposal by incinerators, and elimination of beach pollution. The mayor has power to appoint and remove members of the commission, which will absorb the street cleaning department. The chairman of the commission is to receive $25,000 a year.

The Good Will of the Consumer

Superintendents' Round Table Discussion at Toronto Convention of American Water Works Association

THE best way to handle your consumer is to have a good looking girl at your inquiry window. You cannot beat that combination if she has a nice face and a soft, pleasing voice, because the customers will go away smiling after they have made their complaint. I would rather have a woman handle my consumers than a man. Of course, I always have a man handy so that when it comes down to an argument he is there to explain things, but when you are taking the consumer's money I think a pretty and sweet girl is a combination that cannot be beat.—W. S. Patton, Ashland, Ky.

We have a lady cashier and a man cashier, and they work side by side. The man takes care of the lady customers and their complaints, and the lady takes care of the gentlemen customers and their complaints.—W. S. Cramer, vice-president and manager, Lexington Water Co., Lexington, Ky.

I have found that when you have a dissatisfied customer, in 99 per cent of the cases the best thing is to let him have his say. There is an old saying that if you give a calf plenty of rope he will hang himself. That will pretty well work out in the case of a dissatisfied customer. If you can get him to talk and talk and after he is run down, open up your battery, you will find that the problem is 75 per cent decided. Of course, sometimes the women folks never do run down, but I agree with Mr. Cramer that it is a good thing to have a gentleman look after the complaints of the ladies. I think it is a great mistake to try to argue with a dissatisfied customer.—James E. Gibson, manager and engineer, Water Department, Charleston, S. C.

We send our bills out quarterly, and we read the meter monthly. The object of the monthly reading of the meter is to see that the meter is registering properly, and if we have a very high reading we will notify the customer or leave a card asking them to examine the meter and see if the reading has been correctly taken. Sometimes we send a man to examine the premises, because in that way you will frequently discover a leak. It makes the customer feel satisfied when he discovers that you are taking an interest in his supply.—S. H. Taylor, superintendent, Water Works, New Bedford, Mass.

Some years ago our office staff consisted entirely of men. When a customer came in and saw all men there he would become angry in making his complaint. We decided to employ ladies to collect the bills just for that reason, and we found that it made quite a change. It is a difficult problem to solve when your customer has a bill for $10 and the next one is for $90 and I think it is better to adjust that bill. That customer will never be satisfied if you make him pay that bill, even if you are sure that the water has been used. Do not make the mistake of settling these big bills yourself, or you will have a lot of trouble. The best way is to refer them to somebody else and let them do the settling. We had one customer who came to us frequently with complaints. He had tenants and he never looked after them. We have a practice that when we have a large bill like that in a complaint we issue what we call a customer's complaint, irrespective of whether any complaint has been made or not, and we try to find the reason for the big bill. Usually the girl in the office can make any adjustments when a complaint is made. The heads of departments have no right to give any favors to one customer or another. If one taxpayer uses water carelessly there is no reason why all the rest of the taxpayers should stand the brunt of his carelessness or dishonesty.

It is very poor policy to make adjustments, particularly in a municipal plant. I take the position that in the municipal plant your duty is to serve the public. If you show consideration for one man you should do the same to all. In a private plant if you show consideration to one man, you are simply giving the money of your stockholders away. In a municipal plant you are giving away the municipal funds. At Charleston, a number of times the question has been raised of rebating a high bill as much as 50 per cent. In every case our attorneys have advised us that that is discrimination and cannot legally be carried out. We have three commissioners on the Commission who have paid $90 water bills. When they come to me and ask for an adjustment I tell them that one of the Commissioners has had to pay a $90 bill and that I have no authority to make an adjustment. If they would like to bring the matter before the Commission I would be glad to have that done. Of course, when the matter is brought before the Commission the consumer receives every courtesy and consideration, but the complaint is disposed of in the usual manner, which means that the consumer pays the bill. In one or two instances of these high water bills the consumer does not pay it all at once, but he pays it in small amounts, $1 a quarter, and if he keeps on paying he will get it settled in about 12 years. It usually works out that after he has paid two or three months he gets tired doing that and he wipes out the bill.—J. E. Gibson.

The original question was that of courtesy and good will. I think we all realize that large bills are the paramount factor in dissatisfaction. Originally we used to read the meters and collect monthly all our water bills. Before I went to Omaha they changed over and read the domestic meters every three months. As a consequence, where a leak occurred that was inaudible and invisible, they would make a two-thirds reduction on the bill. Later on we changed that to a two-thirds reduction, assuming that the leak had been found the first month. It makes no difference whether the consumer is a poor laborer or a millionaire, we make the same reduction. In addition to that, whenever a meter seems to be running a little sloppy, and what we think is beyond normal, we notify the tenant that the bill is abnormally high and suggest to him that he look for a leak. We send our inspectors out to find out if there is a leak. I think the biggest factor in regard to courtesy and goodwill is to have a perfectly fair and open discussion with the party who comes in making the complaint and explain to the very best of your knowledge and with patience all the facts in connection with the matter. Try to show him why his bill is high. I think an explanation goes a far way with a reasonable man. Another strong factor is to have employees who have a pleasant manner and a nice method of explaining things.—Theodore A. Leisen, General Manager, Metropolitan Utilities District, Omaha, Neb.

We find one of the best methods of explaining to a customer the reason for a high bill is to check his meter, and follow that up by sending an experienced man to look it over. He takes the customer to the meter and shows the water being registered on the test dial. To show you how it works, we had one of our railway companies that had a 2-in. hose that was left lying on their platform. Several million gallons were wasted in 30 days. The management were not aware that that leak existed. We investigated the matter and found the leak. We found that the man who looked after the water supply had repaired the leak, but we sent the bill into the railway company. Word came back that the bill was out of all possible bounds, and then we gave them the time and date when the leak had occurred and that settled the matter. We have had similar cases in domestic services. Flush tanks in houses are a common source of trouble

because a leak of that kind is something that the householder cannot see, but our expert can take the customer to that tank and show him where the leak is, and show him how it is registering on the meter.—A Member.

Some one in the organization ought to assume responsibility for these matters and settle them there and then. I think the facts should be looked into and the matter thoroughly investigated and before our customer gets to us with a complaint we have the facts looked into. When the customer comes to me I can make what adjustments are required.—S. B. Morris, Chief Engineer, Water Department, Pasadena, Calif.

I have heard a great many things about meters and I want to tell you something that happened last year to one of our best customers, whose bill jumped from $1 to $15 in a month. He came down to see what was the matter, and we called on the old gentleman and asked him what he had done and he said nothing at all. The next month the bill was still $15. We sent a man out to look at the meter. While he was there a man came along with a load of watermelons, and the old gentleman bought one of these melons. Our man said to him, how do you cool that melon, and he said I set it up in the sink and turn the faucet on and let the water run all night; so he paid his $30 for the two months. We rebate all bills that are too high if it can be shown that there is some reason for it. A customer came into the office the other day and talked to the young man who was in charge. He said his bill was $13 and it had never been over $2.25 before. He wrote a letter to the commission and it was referred to me. He came in and I said to him I understand you are real mad about this. I said sit right down and give me all the excuses you have and when you get through I will begin to talk. He commenced to laugh and he said what do you want me to do. I said I want you to go back to your house, and in the morning I will send our man out and he will take your meter out and take it to the testing plant. If that meter is 2 per cent high we will give you this $13 and if not we will make you pay the whole bill. If the meter is wrong we will not charge you. He did not know about that, and I said, do you know what caused that meter to register that amount of water, because meters seldom make mistakes. We sent the man down and found that the meter registered ¼ of 1 per cent under. We charged him the regular rate and split the difference on the other, and that was perfectly satisfactory. We had one case about five years ago where a man had three houses on one meter, and his bill had been running $15 to $18. We could not find what was wrong and he had his entire pipe line taken up. He finally found there was a leak in his flush tank that nobody knew anything about. I do not believe in giving a rebate for one or two months, because if you tell a man that you will rebate one time, he will come back for a rebate again. Is there any one here who has the system of leaving a card at the residence where the people are not at home, and have the customer fill out the reading of the meter?

There was an old rule in our department to compel our consumers to lay their pipes 18 in. underground in the cellar. That was in the early days. In about 50 per cent of the cellars the soil will vary. We find that leaks will occur in these pipes underground. We had one man who was troubled that way and I thought he should get consideration. Our board has reasonable discretion in matters of that kind and tries to make a uniform 50 per cent allowance, but not the whole bill. We charge the consumer the amount of his former bill and allow him 50 per cent of the excess bill. I believe the bills that are sent out are pretty nearly correct. We have one man who pays a bill of $396 or $450 a quarter without any question. —James Sheehan, Memphis, Tenn.

Acknowledgment.—The foregoing is taken from the November Journal of the American Water Works Association.

Cost of Water Purification at St. Louis, Mo.

In his annual report for the year ending April 1, 1929, August V. Graf, Chief Chemical Engineer, Supply and Purifying Section, gives the following information on the operation of this water purification plant of St. Louis, Mo., for the year.

During the past year 47,269 million gal. of water were pumped into the basins. To this amount of water were added 1,924 tons of sulphate of iron and 15,816 tons of lime, or an average of 0.57 grain per gallon of the former chemical and 4.68 grains per gallon of the latter. Aluminum sulphate to the amount of 171 tons was used at the Coagulant House during the year and the cost of this chemical is included in the cost given for iron.

To the 44,547 million gallons of water filtered were added 4,025 of sulphate of alumina and 218,000 lb. of chlorine, or an average of 1.26 grains per gallon of the sulphate and 4.80 lb. per million gallons of chlorine. All of the aluminum sulphate and part of the chlorine were added before filtration and part of the chlorine after.

The average cost per million gallons for lime was $2.81; sulphate of iron, $0.68; sulphate of alumina, $1.61; chlorine, $0.28. These costs are for chemicals alone, and do not include the costs of handling or application. A comparison of the costs of the various parts of the purification work during the past five years, based on the quantity of water delivered to consumers, is shown in Table I.

Water Works in Wisconsin

Of the 2,631,839 people in Wisconsin, 1,423,989, or approximately 54 per cent, are served from public supplies. A study of the sources of supply shows that 30 municipalities, representing a total population of 755,820, secure their water from surface sources; 13, with a population of 211,762, with complete purification; 16, with a population of 543,207, with partial, and one with a population of 851, with no purification. One hundred and seventy-nine other municipalities, with a population of 483,674, secure their supplies from deep wells, and 73 with a population of 184,495, from shallow wells. All well supplies, except four, serving a combined population of 8,236, are without purification. In these four supplies, the waters have been found polluted and are therefore sterilized with liquid chlorine. While only 30 municipalities secure their water from surface sources, this represents about 53 per cent of the population served from public supplies, while approximately 34 per cent are served from deep wells and 13 per cent from shadow wells, indicating that 29 per cent of the state's population is served with water from surface sources, 18 per cent from deep wells and 7 per cent from shallow wells.

Table I—Cost Per Million Gallons—Based on Consumption 1928-1929

Old Plan	1924-1925	1925-1926	1926-1927	1927-1928	1928-1929
Lime	$ 3.57	$ 3.07	$ 2.53	$2.22	$2.81
Iron	.89	.71	.86	1.07	.68
Unloading	.13	.14	.14	.14	.13
Operating, maintenance and repairs	.66	.61	.60	.61	.65
Water, coal, oil, etc	.08	.11	.09	.09	.08
Light and power	.10	.11	.11	.12	.11
Chemical work and supplies	.48	.45	.50	.64	.59
Basin cleaning	.39	.32	.35	.22	.20
Basin repairing	.27	.13	.13	.12	.15
Switching and demurrage	.25	.23	.19	.22	.17
Total—Old Plant	$ 6.71	$ 6.02	$ 5.50	$5.45	$5.57
Filters					
Aluminum sulphate	$ 2.22	$ 2.11	$ 2.33	$1.87	$1.61
Chlorine	.20	.26	.28	.35	.28
Operating, maintenance and repairs	1.17	1.10	1.14	1.07	1.03
Coal, miscellaneous supplies and expenses	.52	.47	.49	.31	.25
Light and power	.38	.39	.42	.39	.35
Switching and demurrage	.05	.05	.04	.04	.04
Total for filters	$ 4.54	$ 4.28	$ 4.70	$4.03	$3.56
Total for purification	$11.25	$10.40	$10.20	$9.48	$9.13
Total consumption for the year in million gallons	41,283	43,389	43,608	42,263	43,204

Progress in 1929 in the Art of Sewage Disposal

Grit Chambers—Detritus Tanks—Sedimentation Tanks—Aerating Devices—Activated Sludge—Chlorine and Sewage Disposal—Sludge Treatment—High Temperature Digestion—Tendencies in Design

By JOHN R. DOWNES
Associate Editor, Water Works and Sewerage

THIS article is an attempt to indicate the latest developments in the design, construction and operation of sewage disposal works and, also, the trend of thought which will influence the designs of the near future.

It is impossible to precisely cut off, and set apart, each year's progress from that of any other year or to ascribe definite developments to certain persons, because the present status of the art has been arrived at by the exchange of ideas over a long period of time. For instance, Waldo S. Coulter of New York, in speaking of one of his latest developments, is able to trace the idea back to the work of Prof. Chas. Gilman Hyde of California in 1926. Meantime Cohn of Schenectady and Hommon of Canton, O., have worked along the same line. More often ideas are subconsciously absorbed and honestly claimed as original by one person much to the chagrin of another who has been possibly hiding his light. All of which makes an article of this type a precarious undertaking and your indulgence is asked accordingly.

Grit Chambers.—In the past much thought has been given to the design of grit chambers with the idea of making a nice distinction between inorganic grit and readily settleable organic solids. The objects of removing the grit are:

To prevent unnecessary wear on pumps, and fine screens.

To prevent clogging of valves and about the base of sludge pipes.

To make available for active digestion processes, space which would otherwise be occupied by the inert grit.

The object of making a nice distinction between organic and inorganic solids which may be collected in a grit chamber, is to leave the grit in such condition that it may be used for fill, or otherwise disposed of, without its becoming offensive to the olfactory nerves.

A development of 1929 is the realization that much of the organic matter which tends to separate at this point may well be disposed of here with much benefit to the balance of the disposal works. This is particularly true since the art of brewing has been transfered from the public brewery to the private home. The spent mash is very heavy and very acid and productive of the most offensive odors which ever occur about the plant. The mash material is almost the equivalent of sand in its clogging effect. Together with mash, a grit chamber tends to collect a mass of large sized vegetable debris, the kind of material which forms scum blankets on settling tank surfaces.

The difficulty of designing a grit chamber to separate only clean, inorganic sand under the tremendous variations of flow encountered in sewage work is too well known to require comment. The economy and convenience of keeping this heavy organic matter out of the sedimentation tank is just beginning to be realized.

The realization of this situation will result in the hydro-mechanical washing of the comparatively small volume of collected grit instead of trying to control the whole, widely varying flow of sewage to so precise a velocity as is required for the proper classification of the grit.

Screens.—The year 1929 seems to have produced little that is original in the screen line.

Alvord, Burdick and Howson, report the installation of a mechanically cleaned bar screen at Aurora, Ill. In this installation the cleaning mechanism operates only when a predetermined difference of head is established between the two sides of the screen. This screen is on a combined sewer and the mechanism operates once in 4 to 5 minutes during storms and only once in an hour or two at other times. More effective screening is thought to be obtained by allowing material to build up a mat on the screen.

Detritus Tanks.—Developing still further the idea suggested under the heading of "Grit Chambers," there is, at present, a marked tendency to introduce skimming and detritus tanks ahead of the sedimentation units. The leading engineers are introducing this feature in nearly all of their designs for larger plants.

Sedimentation Tanks.—Imhoff tanks are still a feature of a number of large designs by leading engineers. Metcalf and Eddy have included Imhoff tanks in plants for 250,000 persons at Akron, O.; and at Dayton, O., and for 128,000 persons at Allentown, Pa.

More and more attention is being given to distribution of flow in sedimentation tanks by the use of high velocity inlets in place of the old open channels and by the introduction of lattice baffles.

Waldo S. Coulter has reverted to the old septic tank provided with lattice baffles and has interposed between the settling tank and such further treatment as may be provided, a 2-story "trap" tank to intercept solids unloaded by the primary unit. Agitation by dropping the primary tank effluent onto a splash board at the entrance of the trap tank, releases entrained gases and allows the solids to settle.

Mechanical removal of the deposited solids from settling tanks is gaining considerable headway as it is bound to do when we realize the importance of prompt and effective removal both to the quality of the tank effluent and to the efficiency of solid digestion.

Aerating Devices.—As primary oxidizing devices the contact bed and the sand filter seem to be ruled out of the modern picture by the very conditions which impose a demand for sewage disposal; that is to say by density of population and high land value.

The year 1929 finds the sprinkling filter still with us and likely to stay for a few decades. This very useful device with its marvelous recuperative powers and its ability to withstand abuse, has, indeed, had its prospective useful life extended by the very system which for a time seemed destined to replace it. Pre-aeration, not only extends the life of the sprinkling filter, or increases its capacity, but also makes possible the control of such odors as have heretofore been more or less definitely associated with trickling filters.

Trickling filters are features of the larger designs for 1929 by the most prominent engineers and, we believe, rightly so. The trickling filter fly has last its terror, since complete control of this nuisance is possible through systematic filter flooding operations. This flooding, which at first threatened to decrease the overall efficiency of the filters, has been developed to a fine art and now actually increases the year around efficiency and makes the periodic unloading problem much less acute. Needless to add that proper provision for flooding is an essential part of the modern design.

Activated Sludge.—It has been said that success for the activated sludge

system appears to be just around the corner; and yet the largest plants now being designed contemplate the use of activated sludge. This is because local conditions of population and land values activated sludge as the only alternative, and makes it necessary to face the problems of power cost and sludge disposal. These large designs provide very flexible arrangements for sludge disposal and the proper solution seems to be only a matter of time and experience.

Power costs are being cut in a few instances by using the gas from the digesting sludge to operate the air blowers. This method has been in use at Plainfield, N. J., for the past two years for operating the aeration unit in summer.

Chlorine and Sewage Disposal.—Some very valuable information gathered by the Chlorine Institute during the past two years has been put to the test during 1929 and chlorine equipment for prevention of odors has practically become standard.

We now have very definite information about the equation by which chlorine oxidizes volatile and odiferous by-products of sewage decomposition to either non-volatile or non-odiferous compounds. Also, we are able to apply the chlorine at the proper point to prevent the odorous compounds from forming or escaping into the atmosphere.

Sludge Treatment.—So far this article has dealt with the treatment of the liquid portion of the sewage. However, the really difficult part of the problem is still, as it has always been, the reasonable and non-obnoxious disposal of the solid material. Near the close of the present year the announcement was made in Philadelphia that the problem of sludge disposal had been met by the invention of a process for drying and incinerating the raw sludge as it comes from the settling tank.

While this announcement was made with all the authority of the Bureau of Surveys of the City of Philadelphia behind it, engineers who heard it, were frankly skeptical of the economy of drying and incinerating 95 per cent moisture sludge.

True, certain work of the New Jersey Experiment Station had indicated, some time ago, that theoretically there is sufficient fuel available in the green sludge to provide for its drying and incineration. There seem to be many difficulties, however, in making this theoretical fuel value available.

High Temperature Digestion.—While Philadelphia is pursuing this investigation further, the New Jersey Sewage Experiment Station is carrying out experiments on high temperature digestion which promise to reduce the time of digestion from 40 days at 70° F., to 10 or 12 days at about 125° F.

Below is a statement from the laboratory on the present status of this work. The point is, of course, that the per capita allowance of sludge space can be reduced to about one-third that required for controlled digestion at 70° F.

"Investigation on Thermophilic Digestion.—The digestion of settled solids at a temperature range of 115-130 has been accomplished. At this temperature common bacteria capable of growing at ordinary temperatures are killed off and a new group of heat-loving (thermophilic) organisms established. These organisms are present originally in sewage solids in limited numbers in an inactive state. When the temperature is raised to 115-130 these organisms multiply slowly and replace the original flora. When the fresh solids are seeded with ripe sludge produced at low temperatures (70° F.) there is a period of biological adjustment and consequently low rate of activity. Once the thermophilic flora is established the decomposition proceeds rapidly. Thus with sludge produced under thermophilic conditions the digestion of fresh solids has been completed under laboratory conditions in 10 to 12 days at 122° F. The yield of gas and the reduction of volatile matter are somewhat higher while the composition of the gas is similar to that obtained with normal temperatures."

Controlled digestion at 70° F. has become an established and effective practice, cutting the time required for digestion from 100 days plus, to 36 to 40 days. The absolute safety with which the methane gas can be collected under floating covers as used at Springfield, Ill., Elyria, O., Plainfield, N. J., Mammaroneck, N. Y., makes the problem of maintaining the 70° temperature very simple.

Samuel Greeley of Pearse, Greeley and Hansen, Chicago, points to the development of inexpensive winter storage for ripe sludge in connection with controlled, rapid digestion as an outstanding feature of his firm's work.

The provision of inexpensive winter storage of ripe sludge is being accepted as a stop gap pending the development of real winter drying, either mechanically, or on sand beds under cover.

In the combination of rapid digestion followed by cheap storage, the sludge is first digested in a well insulated tank provided with a safety floating cover. Heat is cheaply produced from the gas evolved in the process. After the first 36 to 40 days, the sludge is non-offensive and ready for drying. It may then be removed to uninsulated, uncovered, tanks or to lagoons to await spring drying weather. The cost is far less than can be secured by providing Imhoff digestion compartments for winter storage.

Tendencies in the Art.—This development is in line with the tendency of most of the best engineers to make the new designs flexible so that the plant can be inexpensively enlarged or adapted to new developments as their merits are demonstrated.

A note from Fuller and McClintock indicates that they are giving more and more attention to flexibility in sewage treatment and are tending to divide the process into a number of small steps.

Fuller and McClintock's design for the Wards Island plant for upper New York City provides for sedimentation ahead of activated sludge which seems to be an accepted American practice where activated sludge is used. For the present they provide for barging the sludge to sea, while experimenting with the possibilities of fertilizer production.

This same firm provides for barging sludge to sea in the case of New Haven, Conn. At Tenafly, N. J., they report success with the direct drying of the fresh excess activated sludge under glass.

At Middletown, N. Y., this firm is completing a plant where the sludge will be digested in heated, controlled digestion tanks with safety floating covers and will be dried under glass.

From the southwest, Black & Veatch of Kansas City, Mo., report a trend towards activated sludge in their designs. Preliminary sedimentation is consistently included in these designs, as is controlled digestion of both primary and excess activated sludge.

This firm is struggling with the old problem of effective resedimentation following trickling filters, and at Newton, Kan., have added an equalizing tank with a view to producing a nearly uniform flow in the final tank in place of the surges characteristic of trickling filter discharges.

Alvord, Burdick and Howson report a decided trend toward separate, controlled digestion in all their designs for 1929. They report that at Fond du Lac they are consistently securing approximately two-thirds of a cubic foot of gas per capita with variations from 0.6 to 0.75 cu. ft. per capita. This firm stresses flexibility in its new designs and reports that at Aurora particular attention was given to landscaping and a cheap and effective Spanish stucco type of architecture was used to include all pumping, sedimentation and digestion units under one roof.

Reading of English literature and reports of returned travelers from Germany, give the impression of some bitterness of feeling between the proponents of various types of disposal works in those countries. In this country engineers seem to adopt whatever equipment meets the peculiar needs of a particular locality without prejudice. The free and ready interchange of information among engineers in this country has always been a source of wonder to foreign visitors. The great number of Sewage Associations started during 1929 will further the friendly feeling among workers in the sewage field and lead to still freer interchange of information, much to the benefit of the art.

Leveling for Tunnels and Reservoirs

How Surveys Were Made for the Swift River Reservoir Project of the Boston Metropolitan District Water Supply

By LAROY G. HARRIS

Assistant Engineer, Metropolitan District Water Supply Commission, Barre, Mass.

THE base for the levels run on the Boston Metropolitan District Water Supply Project was established, in connection with the U. S. Coast and Geodetic Survey, by running a series of "precise" or "first order" levels from an established Government bench-mark at Springfield, Mass., along the railroads to Boston via Oakdale, Mass. This established a base line from which circuits and spurs were run in and around the proposed Swift River Reservation Basin and to the various shaft sites along the tunnel line from the Wachusett Reservoir to Swift River.

Bench-Marks.—The following rules were followed strictly:

Permanent bench-marks were established at intervals of approximately 2 miles. The line of levels between two bench-marks was broken by temporary bench-marks into sections from 3,000 to 4,000 ft. long, except where special conditions, such as the extremely hilly country which was encountered on some of the cross-country runs, made shorter sections advisable.

The line of levels is broken in this way in order that an error between two permanent bench-marks can be located without re-running the entire distance of 2 miles. This saves considerable time in case an error is made, especially in hilly country where progress is comparatively slow.

No bench-mark was established and designated as permanent unless it was so fastened in rock, brick, or concrete as to resist extraction, change of elevation, or rotation.

At places from which it is likely that future leveling will be extended, at least three bench-marks should be established within a radius of about ½ mile, or far enough apart not to be affected by the same disturbing cause or causes.

Leveling. — Except when specific instructions are given to proceed otherwise, all lines are to be leveled independently in both the forward and backward directions. It is desirable that the backward measurement on each section should be made under different atmospheric conditions from those which occur on the forward measurement, and this is usually accomplished by making the backward run in the afternoon if the forward run is made in the forenoon, and vice versa.

If the atmospheric conditions seem to remain the same throughout the day, the observer should secure as much difference between the forward and backward runs as is possible without materially delaying the work for that purpose.

On all sections on which the forward and backward runs differ by more than the accepted allowable error, which is generally $0.02\sqrt{K}$ (in which K is the number of miles), the section should be re-run until any two runnings in opposite directions check within the limits of the formula.

The length of sight is usually determined by the topographic and meteorological conditions, but should never exceed 400 ft.

The length of sight between the forward and backward stations should be kept as nearly equal as possible by pacing.

When it is expected that the forward and backward runnings of the line are to be completed up to any one place, the elevation at that place should be held by two temporary bench-marks, established at least one set-up of the instrument apart. When the leveling is continued from or to such a pair of points, the instrument should be set up between them and rod readings taken on each point. The same arrangement of points should be used at the completed end or ends of any detached portion of the line of levels. Either one of the two points may be used for carrying along the elevation, with the other used only as a check against mistakes in reading the rod, or a disturbance of one or both of them. By this method, no mistake of a foot made in reading the rod, held on a bench-mark, will escape detection.

The party consisted of five men: Chief of party, observer, recorder, two rodmen, and an umbrella man. The instrument used was a Berger 3-wire Wye-level. The Molitor rods were used, and these rods have shown, after various tests, that no rod corrections were necessary. Steel turning points were used at all times, except when running along railroad tracks; then common tenpenny wire nails were driven into the ties and the head was used as a turning point. The steel turning point was driven into the ground with the aid of a hammer. After the rod readings were obtained as the back-sight the rear rodman pulled his steel pin and moved forward.

Bench-Marks.—The bench-marks used were of two types, one being a ¾-in. round, brass rod, 6 in. long, rounded on one end. The shank of the rod was threaded for a length of 3 in. These rods were grouted in large boulders, ledge outcrop, and concrete bridge abutments.

The other type of bench-mark was an iron rod about 5 ft. long and bent on one end. A hole approximately 18 in. in diameter was dug in the ground for a depth of 5 ft., and there filled to a depth of at least 18 in. with concrete. The rod was embedded in the concrete in a vertical position, bent end down. After the concrete had set, at least 24 hours, a piece of 2-in. pipe was set around the rod, resting on the concrete, so that the top of the rod was about ½ in. below the top of the pipe. A cap prevented the admission of water, and the hole around the pipe was refilled with earth.

All levels for this work were run during the summer months. It is not generally considered good practice to run precise levels during freezing weather as all tripod legs are fitted with metal points which absorb heat and cause more or less settlement when set on frozen ground. Then, again, it is practically impossible to drive steel pins into frozen ground and steel plates are not wholly dependable, as they will also move if left too long on warm days.

The umbrella is used only when the sun is shining brightly enough to cast a shadow. The idea of the umbrella is to keep the sun's rays from affecting the instrument by expansion. When the instrument is being carried from one station to another it should be protected from the sun by covering it with a cloth or canvas hood.

Equidistant Sights.—When leveling cross-country in hilly territory it is practically impossible to keep the instrument equidistant from the back-sight and fore-sight, but the recorder should keep the observer well informed as to these differences so that he can equalize them as soon as possible. If the fore-sight is, say, 100 ft. longer than the back-sight, then the observer, on the next set up, should shorten up on the fore-sight enough to correct this difference, without any expenditure of time for this particular purpose; so at the end of the run the total lengths of the back-sights should approximately equal those of the fore-sights.

The back-sight is generally taken first and the observer reads all three cross-hairs beginning with the top hair. They are read in feet, tenths, hundredths, and thousandths, and immediately recorded. The fore-sight is read likewise as soon as possible after the back-sight to avoid any possible error due to settlement of

the instrument. The wire intervals are immediately worked out by the recorder, and if they do not differ by more than 0.006, which was selected as a maximum, the instrument was moved ahead to the next station. If the wire intervals differed by more than 0.006, the readings were taken again. On some jobs the wire interval is allowed to vary with the length of sight from 0.004 to 0.010, but they were kept low on this particular work for more or less of an experiment, and the final results showed that the error of closure and the percentage of re-running was kept comparatively low without sacrificing speed.

Progress.—The speed in leveling is greatly dependent upon the activity of the observer, the topography of the ground covered, and the meteorological conditions.

The following tabulation shows the speed attained on this work and is based on levels run in and around the proposed Swift River Reservoir Basin. It does not include levels run along the main line from Springfield to Boston:

Working days	45
Average working hours per day	6.75
Total mileage (including "re-runs")	135.0
Average number of miles per day	3.0
Maximum number of miles any day	7.0
Average number of miles per hour	0.44

The average divergence in the forward and backward runs between adjacent benches on double-run lines was 0.0085 ft., giving an average error of closure of $0.009\sqrt{K}$. The average error of closure for single-run circuits (loops) was $0.01\sqrt{K}$. Of these 135 miles, 7 miles, or approximately 5 per cent, were re-run.

Acknowledgment.—The foregoing is a digest for the December Proceedings of the American Society of Civil Engineers of a paper presented by Mr. Harris at the Fall meeting of the society.

Pacific Northwest Water Works to Meet in April

At a meeting of the board of directors of the Pacific Northwest Section of the American Water Works Association held on Nov. 2nd, 1929, at Portland, Ore., it was decided to hold the next annual meeting on April 24th, 25th and 26th, 1930.

At the present time it is planned to hold a golf tournament on April 24th, the presentation of papers and business meeting on April 25th, the dinner meeting and entertainment on the evening of April 25th, the inspection trip covering the local water system, including trip to the Bull Run Dam and headworks, together with other features, on April 26th.

In connection with this annual meeting the following committees were appointed:

Program: Messrs. W. A. Kunigk, chairman; Carl F. Klapp, and R. E. Koon.

Registration and Reception: Messrs. R. J. Disher, chairman; R. T. Wetteland, Sydney J. Benedict and Chester G. Ehle.

Local Arrangements and Entertainment: Messrs. John S. Beall, chairman; H. M. Chadwick, R. C. Polk and E. N. Hallgren.

Golf: W. B. Severyns, chairman; R. H. Corey, E. W. Thompson and Sam Kerr.

Transportation: H. A. Goode, chairman, and C. J. Wagner.

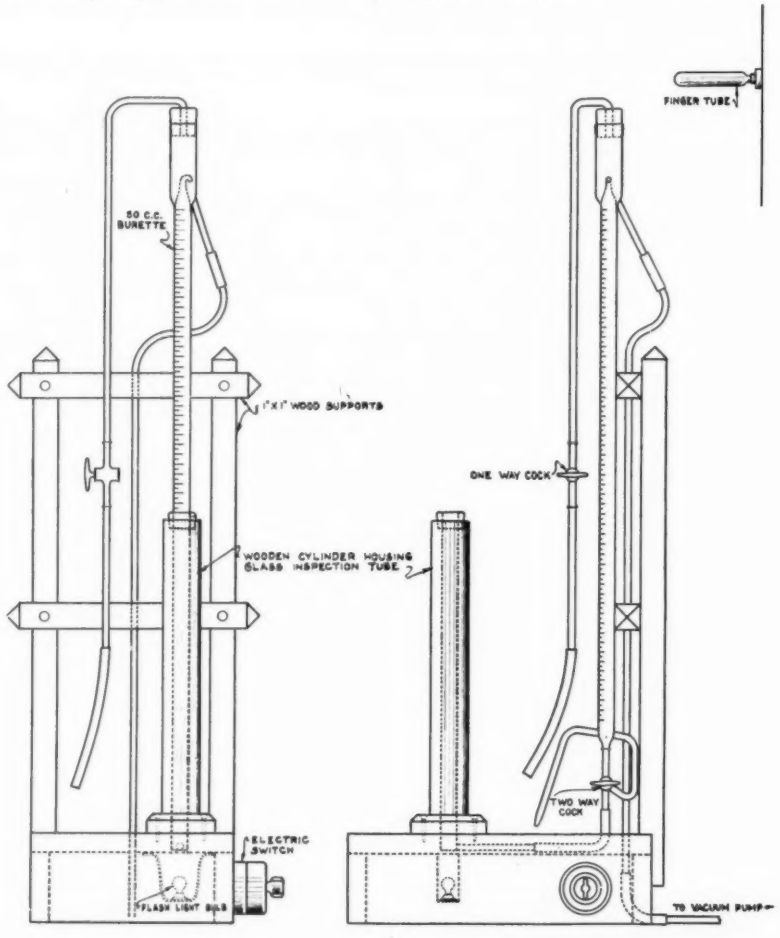
Ernest C. Willard, 720 Corbett Bldg., Portland, Ore., is secretary of the section.

Magnesium Turbidimeter

The hardness of water at the Chain of Rocks filtration plant, of St. Louis, Mo., is calculated from the amounts of calcium and magnesium determined. The method used is that given by Thresh in "Examination of Water & Water Supplies." The calcium is precipitated as oxalate and the amount determined volumetrically. The magnesium is precipitated as magnesium ammonium phosphate and the turbidity produced is determined in the turbidimeter shown. This turbidimeter was designed by F. S. Hawken, Assistant Chemical Engineer. The use of this turbidimeter is described in the last annual report of Leonard A. Day, Water Commissioner of St. Louis.

The sample is drawn, by the vacuum pump, into the burette through the tube connected to the two-way cock. The one-way cock is opened and enough solution is allowed to flow through the two-way cock to fill the small tube connecting the burette to the glass inspection tube. The burette is again filled to the zero mark. The light (a 3.8 volt flashlight bulb in series with a 110 volt, 8 c. p. finger tube) is lit and enough solution is added to obscure the filament of the lamp. This determination is repeated as a check.

A standard containing a known amount of magnesium is precipitated and run at the same time. The standard is so adjusted that practically the same amount of solution is necessary to obscure the filament as is the case with the sample. From the amounts needed to obscure the filament in each case, the amount of magnesium in the sample of water can be computed. This method yields results in practical agreement with those obtained by the gravimetric method.



Details of Magnesium Turbidimeter

Landscape Treatment for Water and Sewage Plants

THE landscaping of the surroundings of water works and sewage disposal plants has been dealt with rather sparsely in engineering literature. At the Third Annual Conference (1929) of the Maryland Water and Sewerage Association three interesting papers were presented on the subject. They are reprinted below.

The Four Dominant Qualities for Landscape Work

By G. W. STEPHENS, JR.
Chief Engineer, The Roland Park Co., Baltimore, Md.

Surroundings of Sewage Plants.—All landscape work, no matter what its size or where it is located, to be a success as an artistic creation must have four dominant qualities, namely, unity, variety, character and finish. The surest way of obtaining the effect aimed at is to be simple in treatment. The true landscape architect aims to produce the best effect by using the smallest variety of kinds in as limited a quantity as possible.

To be permanent, the work must be done step by step in its proper sequence.

Unity.—Professor L. H. Bailey very aptly defines unity as applied to the landscape as follows: "Every planting should be a picture, that is, the area should be set off from every other area, and it should have such character that the observer catches its entire effect and purpose without stopping to analyze its parts. The planting should be one thing, one area, with every feature contributing its part to one strong and homogeneous effect." No one item should be individually conspicuous, but all should help in creating the quiet harmonious whole.

Variety.—When used in this sense I do not mean there should be many kinds of plant material, but there can and should be variety in sky line or contour, in texture of foliage, color, lawn surface, without marring the unity of the place. For instance, while all harsh color contrasts should be avoided, a dash of color here and there among the green can be nicely blended and will add interest. The various characteristic forms of growth, such as horizontal branches against the erect or vertical, make pleasant breaks and give character as well.

Character.—This quality consists largely of being individual or "different" from other places similar in size and outline. It is not easy to define, as the character of a planting is generally the unconscious "touch" of the maker. Just as the "stiffness" or "restfulness" of a room is decided mainly by the appearance and placement of furniture, so character of the planting is dependent on selection and arrangement of material. Each tree or plant should be carefully selected to harmonize, and so placed that it will merge into the general planting scheme.

Finish.—A beautiful planting or lawn cannot retain a permanent, finished effect unless it has the touch of one who is really a lover of plants; one who lives with them, watches their development, and knows their names as well as their appearance. This interest and knowledge is quickly acquired by working among your plants and trees, and personally selecting specimens. Once the flame of enthusiasm has been lighted, you will find yourself observing every planting you pass and taking note of every unusual plant, picturing a place in your planting where it would "just fit." When you have this interest, the shrubbery and flower beds will be kept edged, the lawn kept neatly cut, the hedges evenly clipped, the weeds kept out, and in general, cleanliness and tidiness will prevail. This is the "finish" of the planting.

The sewage treatment plant is commonly thought of as a place to be avoided, and I suppose it is for this reason that so little thought has been given it from a landscape viewpoint.

Heavy screen plantings of flowering shrubs should be used with a few accent points of evergreen trees and shrubs to support the deciduous plantings during the summer and add a touch of life and color during the winter. The buildings should be treated with evergreen and deciduous vines to soften them, and base plantings of flowering shrubs, both evergreen and deciduous, be planted to harmonize with the architecture of the buildings and most important to tie them to the ground.

The walks and roadways within the enclosure of the plant proper and roads leading into the plant reservation should be, in so far as is practicable, curved gracefully to soften the picture and to allow plantings to be made that will screen effectively vistas that may be objectionable from both inside and outside the plant reservation.

Surroundings of Water Plants.—The water plant presents an entirely different problem than the sewage plant. The landscaping of water plants has been given much thought and it is seldom we find the surroundings of them unpleasant.

The small plant as well as the large can be very effectively landscaped with the use of flowering shrubs, both evergreen and deciduous, together with properly arranged perennial and annual borders. By such a combination blooms can be had during all of the summer months and the evergreens will suffice to add the interest needed during the dull months of the winter.

Planting in keeping with the architecture of the buildings is an important part of the landscape setting. Charming planting effects are not the result of chance, but of the studies of men skilled in such matters, who know the soil and the climatic conditions, the growing habits of trees and shrubs, and notably the particular planting scheme to bring out effectively the beauty of architectural styles, and unity, variety, character and finish of the landscape picture most desired.

Important Factors in Landscaping

By M. J. RUARK
Bureau of Sewers, Baltimore, Md.

The following are of importance relative to the landscaping of sewage works:

1. The landscape work where possible should be carried out as part of the initial program, and the cost included in the original estimate;
2. If a sufficient appropriation for the construction of a sewage plant is not available, it is unwise to provide for extensive landscaping at the expense of providing adequate and efficient treatment units;
3. Although it is desirable that a sewage plant be attractive, even under the most favorable conditions it cannot be considered a place for public recreation;
4. Unless funds are available annually for landscape maintenance, this work is likely to result in the forces neglecting operation work in giving more time to cutting of grass, trimming hedges, pruning shrubbery and similar work.

Although the planting of trees and shrubs around and near pumping stations, screen houses and buildings is desirable, such planting, however, should not be placed in the immediate vicinity of trickling filters. Furthermore, narrow strips of grass should not be planted, as they are usually very hard to maintain. While the planting scheme should be attractive, it is doubtful whether there should be any attempt to produce elaborate effects. Dried sludge makes a good filler or substitute for top soil, and there is little difficulty in keeping the grass areas in the vicinity of a sewage plant healthy. On the other hand, the lawns may require

mowing more frequently than in parks, or water-works plants.

Even though funds are not available for a complete scheme of landscaping, nevertheless, rank grass and weeds should be kept cut, swampy areas should be drained, as they provide a breeding place for gnats and mosquitoes, and detract from the appearance of the sewage plant.

The Value of Beauty

By JAS. W. ARMSTRONG
Bureau of Water Supply, Baltimore, Md.

It is important that those entrusted with planning and designing of public improvements should have an appreciation of the value of beauty. The marked improvement in architectural and landscape work in this country in recent years, shows that public taste is gradually reaching a higher plane, and as time goes on the public will demand well designed buildings with attractive surroundings.

Public buildings and grounds are silent witnesses to public taste and have much to do with the standards adopted by private citizens in their places of business and home surroundings. I remember hearing a speaker at a convention describing the influence of good roads on a community. He told of a dirty and neglected street lined with dilapidated and shabby looking houses. The street was repaved with asphalt and almost immediately changes began to take place. Broken window lights were repaired, shutters straightened, painting was started, front yards were cleaned, grass and flowers began to appear, and in the course of a few months the transformation was truly remarkable. All because a conviction had taken hold of them that an attractive and clean street demanded the same kind of homes.

I am making a plea for those who have the planning of public works, to study the aesthetic side of your work along with the utilitarian side.

Lack of funds is the excuse sometimes offered for ugly looking places, but that is generally not the real reason, as good looks can often be secured with little or no added expense.

I have seen buildings and grounds with much money spent on them, obviously for the purpose of adornment, that were ugly; and othere that were made beautiful simply by a skillful massing and proportioning of the buildings and by observing a few simple requirements for planting. If the matter of beauty is not kept in mind during the designing period, it will probably be impossible to remedy the trouble later. I know of a public building recently constructed that was so unsightly that the neighbors complained of it. The officials in charge are now making an effort to remedy the trouble by plantings, but their efforts are too late to ever secure any pleasing effect.

Many city employees inherit ugliness in the surroundings under which they are required to work. Their problem is a very different one from the designee, yet some of the same principles may be applied to the improvement of their places. By the judicious use of a little money and a vision of the possibility of beautifying a place, a plant superintendent may become a real public benefactor.

A few simple suggestions may be of service. An unattractive looking building may be transformed into a thing of beauty by covering it with vines, such as the Boston Ivy or by planting the Boston and English Ivy together, whereby a touch of green may be maintained through the winter. An unsightly building, a coal or ash pile, may be screened from public view by planting closely around it such trees as the Lombardy Poplar, and in front of these may be planted tall growing flowering shrubs, and in front of these shrubs of lesser height. In this way a mass of beautiful foliage can be secured at very little expense. In planting small areas, it is always well to preserve as much lawn surface as possible, and if trees and shrubbery are planted around the borders of the property and in the back ground with occasional plantings against the buildings, a much more attractive appearance will be secured than if the center of the lot were cluttered with trees and bushes.

The unexpected sight of a beautiful tree or cluster of plants or a vista revealing a beautiful view that could not be anticipated always add to the charm of a landscape. The element of surprise which generally enhances beauty can be better secured by making the outline of planning follow irregular curves than by using straight lines. Before an attractive appearance can be secured in some places, it is necessary to regrade the grounds. In such cases, it should be remembered that steep terraces with sharp horizontal lines at the top and bottom are not pleasing to the eye and are seldom found in nature. Gentle slopes with curves at the top and bottom look better, are less expensive to maintain and they also permit the easy operation of lawn mowers.

If terraces must be maintained they can be beautified by the close planting of shrubs. Those who have observed unsightly paths across parks and public squares, know that most people, whether they have studied geometry or not, realize that the "shortest distance between two points is in a straight line." Such paths may be prevented in one of two ways. By plantings that prevent short cuts or by making walks follow the natural lines of travel. Walks following gentle curved lines are more pleasing than straight walks, provided the curves do not give the appearance of being uselessly introduced for effect.

Broad leaved deciduous trees are objectionable for planting around open reservoirs for the reason that the leaves are blown into the water, but pines and other conifers are free from this objection.

Efficient Methods in Private Reforestation Program

The Nekoosa-Edwards Paper Co., which is carrying on an extensive reforestation program in the state of Wisconsin, has found that good organization and large-scale planting bring down costs, according to F. G. Kilp, chief forester, in a paper presented at the 21st annual convention of the Engineering Society of Wisconsin. In 1928, 470 acres were planted at an average total cost of $5.66 an acre. This is a reduction from $6.51 an acre in 1927 and $11.00 in 1926. On large-scale work, 1928 costs averaged as low as $4.18 an acre.

"We prepare our planting ground," says Mr. Kilp, "by plowing furrows every 6 or 7 ft., the spacing depending entirely upon the amount of natural reproduction growth on the ground. A 10-ton Caterpillar tractor pulling a 24-in. brush-breaking plow is used for plowing the ground. The furrows are plowed as shallow as possible, depending entirely upon the underbrush growing on the area to be planted. In general, the depth of furrows is from 3 to 4 in. Oak brush from 1 to 4 in. in diameter has no effect on the plowing or equipment. Between the plowing and crushing effect of the tractor on the brush, from 25 to 40 per cent of the natural competition is removed to assist the seedlings in getting a good start after being planted in the field.

"Experience has taught us that by starting to plow from one corner of a 40-acre section and continuing around and around until the center is reached, our plowing costs are reduced. The former method was to plow clear across and through on the line each time. The new scheme also increases fire protection for several years hence, since the furrows run lengthwise on each side and parallel from opposite sides to the middle.

"The planting crews usually consist of from seven to twelve men and a foreman. Each man carries his own trees in a light box with the roots packed in moss to keep them from dying out, and a spud for planting. It takes several days to organize a crew properly, or to bring it up to its proper efficiency. After a few days of planting experience each man is expected to plant on an average from 2,200 to 2,400 trees a day. It is back-breaking work and only young, strong backs respond to the strenuous daily exercise. Good supervision means, as a rule, good planting survivals."

The New Water Supply of Sioux Falls

New Type of Wells, Iron Removal Plant and Diesel Pumping Equipment

By F. G. GORDON

Gordon & Bulot, Consulting Engineers, Chicago

THE Sioux Falls, S. Dak., water supply is obtained from shallow wells located in the broad river valley of the Big Sioux River, north of the city. From these wells it is pumped to an iron removal plant, and from the reservoir under the iron removal plant by a second pumping into the distribution system. The pumping equipment at the wells is all motor-driven, while the high service pumps are driven by Diesel engines, with the exception of a motor-driven centrifugal pump used for standby service. There are three elevated tanks and one standpipe located on the distribution system.

The sand and gravel stratum from which the water comes apparently covers a very wide area throughout the river bottom. This stratum lies under a top soil approximately 10 ft. deep, and over a dense clay blanket found at a depth of 35 to 40 ft. below the surface.

The present supply comes from two large circular, open wells, each 50 ft. in diameter, and from five closed wells of a type invented and patented by Mr. Maury, the writer's partner up until the time of his retirement from active practice.

The New Wells.—The design of these wells was made with the idea of securing certain results which could not be obtained with any other type of well in use. It was desired to have a well in which horizontal motor-driven centrifugal pumps could be placed, a well which would prevent any contamination in any way, and a well which would have an enormous strainer area. All of these things have been accomplished in the type of well used.

The lower portion of the well shaft has a strainer area extending completely around the circumference, which permits the water to enter the well. The diameter of each well is 18 ft. In each well there are 4,216 2-in. holes, having a total area of 92 sq. ft. Since these holes are distributed around a circumference of 56 ft., 6 in., there is ample opportunity for water to enter the well without excessive friction loss. In order to prevent sand flowing into the well through these large holes, eight pockets are constructed around the inner circumference. The design is such that concrete columns are located between the pocket, thus providing a rigid cylinder. These pockets are filled with fine gravel on the outside face and very coarse gravel away from that face. The fine gravel next to the outside is held in place during the sinking of the well by a screen which is placed on the inner face of the outside plate. On the inner face of the pockets ½-in. steel plates, punched with 1-in. holes, permit the water to enter the well freely. The width of these pockets from the outer face to the inner face is 2 ft.

Immediately above the strainer section of the well is placed a concrete bulkhead. This serves as a floor on which are located the horizontal motor-driven centrifugal pumps. In some of the wells two pumps have been installed, while in others only one pump has been placed. Each well is constructed, however, with two suction pipes, passing through the concrete bulkhead into the strainer area. A third pipe extends through the bulkhead and is carried up to the level of the floor of the well house. This pipe permits measurements to be taken directly to the water level, and is also used for the installation of a Bristol recording water level gauge.

Seven-day charts are used on this gauge, and these charts provide valuable information. They show for each well the ground water level throughout the year. They also show the drawdown of each well when pumping, and the hours that each well pump is operated.

How the Wells Were Constructed.—The manner of constructing one of these wells is quite simple. The top soil at the location of the well is removed and the steel work for the strainer section erected in this hole. The concrete which forms the cutting edge, and the concrete for the triangular columns located between each of the gravel pockets, is next poured. A clamshell or orange peel bucket is then used to excavate from the interior of the well, and as material is excavated, the well sinks. Sixteen gauge steel plates, bolted together with stove bolts, serve as the outside form for the circular well wall. When enough material has been excavated from the interior of the well so that the well has sunk a distance of 4 or 5 ft., a section of wall of that height is poured, the inner forms removed, and the excavation and sinking continued for another four or five feet, when the operation of pouring another ring of concrete is repeated. This process continues until the cutting edge at the bottom of the well reaches the top of the clay, some 35 or 40 ft. below the surface. Water is encountered some 10 or 12 ft. below the surface and the sand and gravel below this point is, of course, removed in the wet.

The well having been sunk to the clay, the next step is the placing of the concrete bulkhead. The wall of the well is so formed that a shelf or ledge exists at the top of the strainer section. A circular form of the cross-section of the interior of the well is assembled on the ground adjacent to the well. Holes are placed in this form at the proper location for the two suction pipes, and the test pipe. The form is then placed immediately over the top of the well and the two suction pipes and the test pipe are inserted through the holes previously made in the form and are bolted to the form so that they are held rigidly in a perpendicular position.

Each of these pipes has a valve at its upper end, which is in the proper position to be about 12 in. off the bulkhead floor when it has been poured. These valves are closed and are covered with burlap or other material and the form, with the suction pipes and valves, is then lowered through the water until it rests on the ledge immediately above the strainer section. Concrete is **now deposited** on this form by means of closed buckets. These buckets have a bottom door which can be unlatched to allow the concrete to be emptied when the buckets reach the top of the form. By this method the concrete for the bulkhead is deposited under water up to an elevation six inches lower than the finished bulkhead floor level. **During this** process the water on the inside and the water on the outside of the well are at the same elevation.

The next step in the process is to place a layer of grout on top of the already deposited concrete. While this is being done, the water level on the interior of the well is carried at an elevation higher than the ground water level outside of the well. This difference in hydrostatic head forces the grout into the concrete and insures a water-tight floor. In the five wells of this type which have been constructed for Sioux Falls, no trouble has been experienced in any of these wells in making the floor water-tight.

After the concrete and grout have set up, the water on the inside of the well is pumped out, thus leaving a dry pump pit. The pumps, together with their discharge piping, are then installed, the valves on the suctions are opened, and the pumping equipment is ready for operation. Since the static ground water level is higher at all times than the elevation of the top of the pump casings, these pumps are primed at all times. All of the well pumps are operated from the main pumping station.

Pumps Installed in Rafts.—Rather interesting installations have been

made in Wells 3 and 4. These are the two large circular wells previously described. When first installed each was equipped with a vertical motor-driven deep well pump. The lack of high efficiency of the vertical pumps and the need for an emergency unit for each well suggested the possibility of placing in each well a horizontal motor-driven centrifugal pump on a raft. Rafts were constructed, each consisting of a wooden platform mounted on steel oil barrels. An I-beam was bolted vertically to the interior wall of the well and a yoke, with rollers, was fastened to the raft in such a manner that with a raising or lowering of the water level in the well the rollers move up and down on the inner faces of the outstanding flange of this I-beam. Flexible hose connections are installed from the discharge of the pump to the pipe leading from the well to the iron removal plant. These installations have been in service for twelve years and have required very little attention, outside of an occasional renewal of the hose.

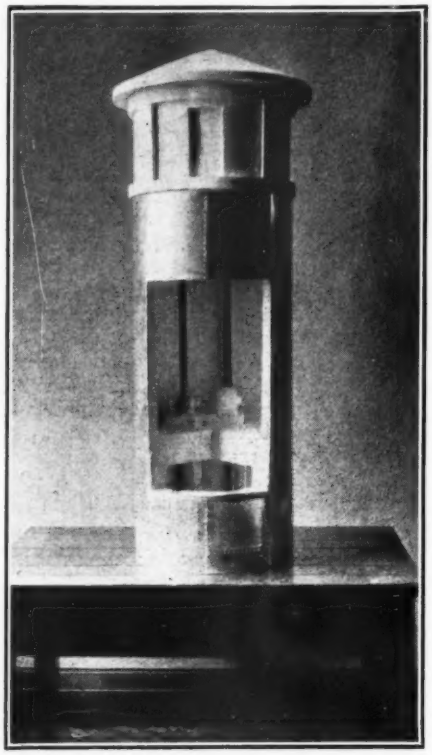
The Iron Removal Plant.—Strict economy dictated the use of several of the more unusual features in the 8-m.g.d. iron removal plant, built at a cost of $11,125 per million gallon capacity. Small filter units permitted hand operation of the valves. Recording water level gauges on the filter effluent line replace the ordinary integrating loss of head gauges. A spent wash water storage sump spreads out the discharge so that a smaller drain answers. The underdrains consist of a steel plate false bottom, into which nozzles are screwed.

Before preparing final plans, an experimental plant was operated to determine whether aeration, followed by sedimentation and filtration but without the use of chemicals, would remove the iron satisfactorily. As the results with the experimental plant indicated a 96 per cent removal, it was decided to employ this process in the contemplated plant.

Rate Controller and Gauges.—A new type of rate controller manufactured by the International Filter Company was used in this installation. This controller is of the Venturi type, with a butterfly valve operated by a diaphragm. Tests, in which the head on the inlet side was varied from 2.5 to 5 lb. in an interval of one minute, showed a variation in discharge of less than 5 per cent.

Recording water level gauges were used for loss of head gauges. The gauges for adjoining filters were mounted back to back on 1-inch gauge boards located on the operating floor. Although this type of gauge is not differential in its action, it gives a satisfactory record because the water level in the filters is carried within a few inches of the same elevation at all times.

Since a single wash water pump is provided, for emergency use a connection is made to one of the high service mains leading from the pumping station to the distribution system. The friction loss through this connection was carefully calculated, and the size of the pipe selected so that the wash water pressure when delivering a sufficient quantity for washing purposes would not be excessive.



Model Showing Construction of Well

A sump having a capacity of 40,000 gal. was constructed to receive the wash water from the filters. The construction of this sump permitted the use of a 10-in. cast-iron drain from the sump to the nearest city sewer instead of the 16-in. drain which would have been required if the sump had not been built. The saving due to the use of the smaller drain amounted to $5,887, while the cost of the sump was only $1,617. Cast-iron construction for the drain was necessary because of its proximity to the gravel stratum from which the water supply is obtained.

The office, laboratory and pump room are located at the front of the filter plant building. The pumping equipment, which is all motor-driven, consists of a wash water pump, three auxiliary low-lift pumps, which can be used as boosters to assist the well pumps during the periods of low ground water, and one high-service pump.

Clear Water Reservoir.—Beneath the iron removal plant is located a clear water reservoir, built several years prior to the construction of the iron removal plant. This reservoir is 116 ft. square and has a capacity of 1,200,000 gal. The construction is of interest in that the floor of the reservoir is composed of a series of inverted groined arches. At the time this reservoir was built the ground water level was some 4 or 5 ft. higher than the bottom of the reservoir and the design was influenced by this fact. The city guaranteed to keep this ground water level down during the construction of the reservoir and was thus able to secure much lower bids than would have been the case had contractors bidding on the work given consideration to this contingency.

The city had four 10-in. wells sunk, one at each corner of the reservoir and connected these wells to a suction pipe leading to one of its high service pumps. By operating this pump during the period of construction, no difficulty was experienced in keeping the ground water level safely below the bottom of the excavation for the reservoir.

After the reservoir had been completed, the four wells were capped with check valves opening in to the reservoir, thus permitting water to flow into the structure whenever the water level on the interior was lower than the ground water level on the outside.

Diesel Engine-Driven Pumps. — In 1915 the city decided to install Diesel engine-driven pumping equipment for regular service, and to relegate its steam-driven pumps to standby or emergency service. Two Busch-Sulzer engines, each of 160 H. P., were selected to drive Aldrich triplex pumps, each having a capacity of 1,600 gal. per minute against 190 ft. head. On each engine shaft was mounted a generator of 135 KVA capacity. A friction clutch installed between the generator and pump permitted the pump to be cut off from the engine and the generator operated as required. These Diesel engine-driven triplex pumps have been in service continuously since their installation and have been entirely satisfactory. In 1926 the city added to its Diesel engine equipment by installing a 400 H. P. McIntosh & Seymour engine, with a 270 Kw. generator mounted on the engine shaft and driving a horizontal Worthington pump through a friction clutch. All of the Diesel engines are of the four-cycle air injection type. Fuel oil is supplied from small tanks overhead which are in turn filled from large steel storage tanks located at the south end of the station building. Cooling water is from the city mains.

Acknowledgment—The above is an abstract of a paper presented before the Missouri Valley Section of the American Water Works Association.

Water Works and Sewers in Illinois.—Of the 1,113 cities, villages and inporated towns in Illinois 508 have public water supplies, and 411 have some form of public sewer system. Of the 411 sewer systems 154 were installed as combined storm and sanitary sewers, 142 as separate sanitary sewers and 115 as mixed systems of sewers and drain tiles.

Sources of Water Supply in Southern California

Rainfall—Effect of Altitude on Rainfall—Rainfall Cycles—Disposal of Rainfall—Mountain Runoff —Water Supply from Rainfall on the Valley Floor—Ground Water Basins

By A. L. SONDEREGGER
Consulting Engineer, Los Angeles, Calif.

IT is a matter of general comment among the population of Southern California that of late years we have passed through a period of draught. We have had one dry year after another; in fact, since the great floods of 1914 and 1916, we have had only three years of abnormal rainfall, while the other ten years have been dry. Yet we keep on pumping cheerfully from seemingly unlimited underground sources and nobody appears to worry very much except the superintendent of the water works.

The assertion is sometimes advanced that there are mysterious underground streams, or rivers, which convey water from the Mojave Desert to the Coastal Plain, or from as far distant sources as the Colorado River. There are no indications, or facts, in support of any such contentions. The mountain ranges which separate us from the desert are plutonic in origin. They are many miles in thickness and there are no passages, or cavities, to permit either a flow or a percolation of water across them.

Rainfall.—The water supply of any region in Southern California depends entirely upon the rain falling on its contributary watershed and a study of rainfall phenomena will, therefore disclose the basic factors affecting our water supply.

The major storms which drift from the Pacific Ocean over Southern and Central California are the result of areas of low barometer, usually moving from northwest to southeast. These storms are the most frequent bearers of our rainfall. They are general over the whole region and, as a rule, of fairly uniform relative intensity. The records of seasonal precipitation of any station thus are an index for a broad area.

Effect of Altitude on Rainfall.—The moisture-laden storm winds strike the coast from the southeast, south and southwest. On encountering the mountains along the coast and in the interior, they are forced to rise to higher altitudes, where they are cooled and precipitate a larger portion of their moisture. Thus with increasing altitude, we find correspondingly larger precipitation up to about 6,000 ft., above which there is a slight decrease. This process of absorption of moisture is so effective that after passing the succession of ranges which parallel the coast, there is little moisture left beyond the High Sierras, and the country to the east thereof is naturally barren. This phenomenon is illustrated on Plate 1, which represents a profile transverse to the major axis of the state, from the Coast of San Luis Obispo easterly across the Santa Lucia Range to the San Joaquin Valley and thence over the High Sierras to Owens Valley and Death Valley. This is also illustrated on the same plate by a profile from the coast at Long Beach across the southern Coastal Plain and San Gabriel Valley, passing Mt. Wilson of the Sierra Madre Range and on down to Palmdale in the Mojave Desert.

Rainfall-Cycles.—The rainfall of Southern California is characterized by extreme irregularity, not only from day to day, or month to month of a rainy season, but also from year to year. Yet, while there is an apparent irregularity of seasonal rainfall, it has, nevertheless, been established that within broad limits the fluctuations over long periods of years follow fairly well-defined laws, it being apparent that there are periods of wet years followed by dry periods. The duration of a complete cycle, consisting of a wet and a dry period, is 20 to 24 years; 10 to 12 years in which the average rainfall is above normal, followed by a like period in which it falls below normal.

This phenomenon naturally affects the water supply of the country to the extent that the fundamental problem with which the water supply engineer is confronted, is that of regulating an erratic supply.

Over long periods of years, the consumption of water, through plant growth, corresponds to the average rain. During a series of wet years, with precipitation above normal, there will, therefore, be an accumulation of the surplus water reflected in heavier and deeper saturation of soils, larger stream-flow and rising groundwater levels. An occasional dry year in a wet period will only temporarily check the increase. On the other hand, a dry period will cause the gradual depletion of the water supply. This phenomenon is illustrated in Plate 2, Figs. 1 and 2, which graphically show the seasonal rainfall at Los Angeles and the runoff of the San Gabriel River at Azusa for the years 1871 to 1924.

Fig. 3 of the same plate shows the Mass Diagram, sometimes called "Residual Mass Curve" of the rainfall for Los Angeles, platted so as to show the accumulative effect of the departure from the normal rainfall for the 53-year term. A rising line indicates a rainfall for a season above normal, and a falling line, a shortage. The general downward slope of the dash-and-dotted line denotes shortage over a period of years and consequently a gradual draft on the accumulated water supply, while ascent of the dash-and-dotted line indicates gradual storage of the surplus.

The mass curve then represents what would be the fluctuation of the water level in a tank exposed to the rainfall, from which annually the average amount of precipitation for the 53-year term, namely 15.01 in., is extracted.

A similar illustration is presented in Fig. 4 relating to the seasonal runoff of the San Gabriel River. The mass curve here presents again the fluctuation of the water surface of a reservoir in which the entire runoff would be impounded, with annual abstractions equivalent to the mean recharge for the 53-year term, namely 135,800 acre feet. It should be noted that seasonal fluctuations of stream-flow are much more erratic than those of rainfall. The periods of depletion and accumulation are clearly indicated as follows:

	1871-83 Dry	1883-93 Wet	1893-1904 Dry	1904-16 Wet	1916-24 Dry
Average Seasonal Rainfall at Los Angeles	13.83 in.	20.32 in.	11.25 in.	16.90 in.	12.47 in.
Average Seasonal Runoff San Gabriel River	97,258	224,470	52,427	187,492	120,162
53-Year Mean San Gabriel River 135,800 Acre Feet 100%	138%	89%	72%	165%	39%

The runoff or water supply produced by the San Gabriel River in the driest period of record, 1893-1904, was only 28 per cent of the succeeding wet period. For these two periods, stream gaugings exist for a sufficient number of years to make the results reliable. In order to equalize a water supply like that of the period from 1883 to 1904 to an average of 135,800 acre feet per annum, storage capacity of nearly 1,000,000 acre feet would have to be available, or about four times the capacity of the proposed San Gabriel Reservoir.

Fig. 5, Plate 2, shows the fluctuations of a well at Baldwin Park in San Gabriel Valley for each year. The well responds to the variations in stream-flow and rainfall. The groundwater basin of the San Gabriel Valley is, therefore, comparable to the tank above mentioned, and, as a matter of fact, operates as such. During a wet period

this basin gradually fills with seepage water, both from the streambeds which traverse the valley and from direct percolation of rainfall, so that the water levels in wells keep on rising until this tide turns and the dry period sets in. Inasmuch as it is the function of a reservoir to be drawn down during dry years and to be replenished in wet ones, the lowering of the water-table, as a result of years of drought, does not indicate or prove that the basin is overdrawn. The criterion of an overdraft is the non-return to original levels at the end of a wet period.

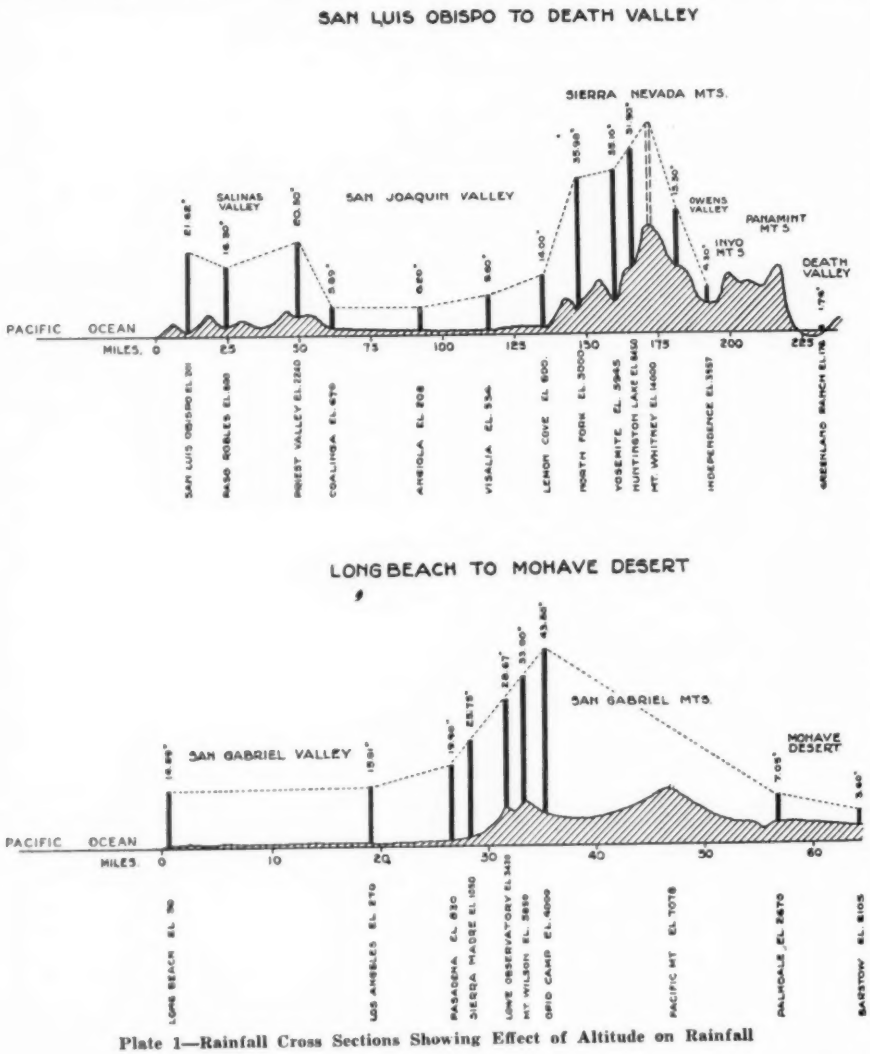


Plate 1—Rainfall Cross Sections Showing Effect of Altitude on Rainfall

The diagrams of Plate 2 show the cyclic fluctuations as determined by observations of rainfall, stream-flow and groundwater levels. In Southern California the water crop of dry periods is supplemented by cyclic underground storage. Dry years are particularly critical for the water users relying upon surface flow. The water supply must be gauged by the dry years crop, and storage is required to regulate the excess flow of wet years. The development of a country based upon the supply of wet periods will sooner or later lead to economic disaster. The present status of the science of astronomy and the related science of meteorology do not permit of periodical weather forecast. Predictions as to our future water supply, therefore, must be based entirely upon records of past performance. Under such conditions, the records of the driest period available, combined with the possibilities of cyclic storage, must be taken into consideration in estimating the available supply, particularly where domestic supply is concerned.

Disposal of Rainfall.—Generally speaking, a portion of the rain falling on an area will seep into the ground at the point where it falls; another portion may flow for a distance on the surface or collect into drainage channels, there to seep away unless the storm be heavy enough to produce a runoff on the surface beyond the limits of the watershed, or even as far as tidewater. This "surface runoff," which takes place during a storm or for a few days following, is also termed "storm-runoff."

The rain water which seeps into the ground saturates the soil to various depths, depending upon the magnitude of the storm. This seepage is, in turn, subject first to evaporation from the surface of the ground—second, to absorption by plant life—and, third, to deep percolation beyond the roots of plant life and beyond the limits of capillary action, depending upon soil formation and moisture conditions. Deep percolation may subsequently drain into gullies and creeks and thus form the normal flow of a stream which occurs between storms and with perennial streams also during the summer. The normal flow of a stream is therefore a seepage-runoff, seeping into the ground first and thence draining therefrom.

The evaporation and transpiration losses are generally called the "consumptive use," which is essentially a function of the character and type of soil and the soil cover.

Rainfall is therefore disposed of as "consumptive use," "seepage-runoff" and "storm-runoff."

This disposal of rain water takes place on the valley floor as well as in the mountains, and both types of watersheds share in the production of our water supply.

The relative effect of rainstorms of various intensities leads to the conclusion that the largest contributions to our water supply are produced by storms of great intensity, which last over several days and produce valley rains of 8 in. to 12 in. for the storm. Such storms produce a large storm-runoff from our mountains. On the other hand, in the valley they are the cause of the deep percolation which recharges the groundwater basins. A study of the effect of individual storms on stream-flow and on the fluctuations of the groundwater table, will be found to be very instructive. As a rule, a wet winter will produce one storm of outstanding intensity, which is responsible for the greater portion of the watercrop of the season.

Mountain-Runoff.—On a mountain watershed with residual soil cover, seepage water may strike bedrock at a depth of 1 to 12 ft., or more, there to be diverted downhill (see Figs. 3 and 4 of Plate 3). On its downhill course this percolating water has to run the gauntlet of absorption by the roots of trees, brush and herbs which may have penetrated fissures to depths of 20 to 30 ft. Abstraction therefore is extremely active until the percolating water reaches the streambed. Despite this continued tapping, however, seepage runoff is produced in dry years, although this may, in part, be due to over-year storage and partly to absorption in talus slides which, owing to their unstable and porous formation, readily admit the rain water.

The runoff of a mountain watershed is, as a rule, measured at the mouth of canyons and includes both the seepage, or normal, runoff and the storm-runoff. It is the runoff that becomes available for water supply. Measurements of flow on the major streams are made by the U. S. Geological Survey

and the results published in its water supply papers. The runoff figures of the San Gabriel River used in the preparation of Figs. 2 and 4 of Plate 2, were obtained from the water supply papers of the U. S. G. S.

The consumptive use of a mountain watershed for a 12 months season is obtained from the equation

Consumptive Use=Seasonal Rainfall —Runoff.

A study of the daily discharge of a stream and its hydrograph will readily permit the segregation into seepage and storm-runoff, since the latter is characterized by the violent and erratic departures from the more or less uniform normal flow.

For the mountain watersheds it has been found that the consumptive use of the brush or timber cover varies from 20 to 30 in., and that this is, roughly speaking, two-thirds of the rainfall or total water supply. Of the remaining one-third, by far the larger portion is normal or seepage-runoff and only a small part is storm-runoff, except in years of heavy floods. The San Gabriel River, with a watershed of 222 square miles above Azusa, has an average seasonal runoff at that point of 135,800 acre feet, or 600 acre feet per square mile, equivalent to a depth of water spread over the watershed of 11.3 in. The average rainfall on this watershed may be estimated at 31 to 36 in., or about three times the average runoff. For smaller watersheds and lower altitudes, the consumptive use is a still larger percentage of the rainfall and the runoff correspondingly smaller.

The fluctuations of runoff of individual years are even more erratic than the periodical fluctuations. The minimum seasonal runoff of the San Gabriel River occurred in 1898-99 with 9,630 acre feet, equivalent to a depth of water over the whole watershed of less than 1 in., and the maximum in the season of 1921-22, with 410,000 acre feet.

Water Supply from Rainfall on the Valley Floor.—Seepage water penetrating intermittently below the limits of evapo-transpiration activity must ultimately cause the wetting to field capacity (or water capacity), either of the entire formation overlying the water-table, or of well-defined ducts reaching from the surface to the water-table. If there is additional seepage from above, there must be a corresponding addition to the water-table.

The alluvial deposits of which the fill of our valleys is made up are essentially heterogeneous in formation, consisting of irregular bodies of sand, gravel and clay, so that the percolating fluid will naturally find lines of least resistance, to the effect that a uniform saturation over large areas and to great depths is not likely to occur, but rather, the formation of more or less defined ducts.

At points where percolating water strikes an impervious stratum, downward movement is interrupted and a suspended water-table formed. Gradually, lateral percolation is then established and a circuitous route for the percolating fluid is formed until another pervious deposit again permits of more or less vertical movement. Whenever a suspended water-table has been formed, the drainage from same will occur over the edges of the impervious stratum and is likely to collect into trickling streams, as illustrated in Fig. 1, Plate 3. These conclusions are supported by the fact that during the process of excavating shafts in alluvial fills, it is quite common to strike dry materials alternating with moist materials and occasional streams of water. Inasmuch as alluvial deposits almost invariably show an alternation of pervious and impervious strata, the phenomenon indicated in Fig. 1 is probably the one most commonly encountered. Under such conditions, only a portion of the alluvial mass between the surface and the groundwater table will be saturated.

The recharge of the groundwater may be hastened or delayed by impervious strata. Large clay bodies may not only cause a regulation of an irregular water supply, but they may also provide storage of a magnitude not appreciated because not readily traced.

Absorption is favored by the wedging

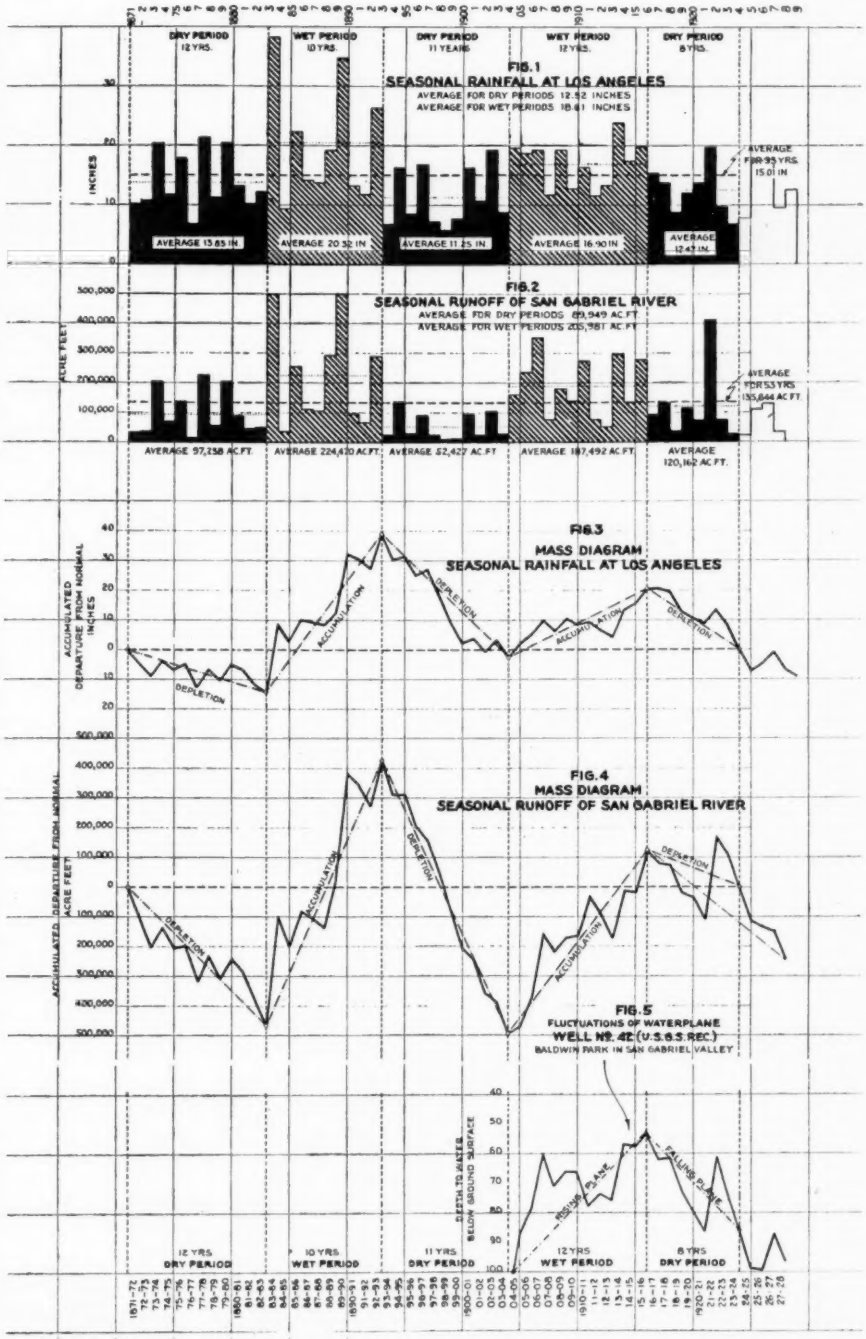


Plate 2—Civic Fluctuations of Water Supply. Averages Computed for Period 1871 to 1924. The Mass Curves of Figs. 3, 4 and 5 Have Been Extended to 1928 to Show the Effect of the Continued Drought

action of roots and especially by decayed roots, the latter having a tendency to drain a saturated mass along defined canals.

The intensity and effect of rainstorms is magnified by the irregularities of topography, whether they are the depth of the root zone, is not likely to occur, with the ultimate result that larger portions of the valley rains reach the water-table than is commonly assumed.

The quantity of the water supply resulting from rainfall on the valley floor

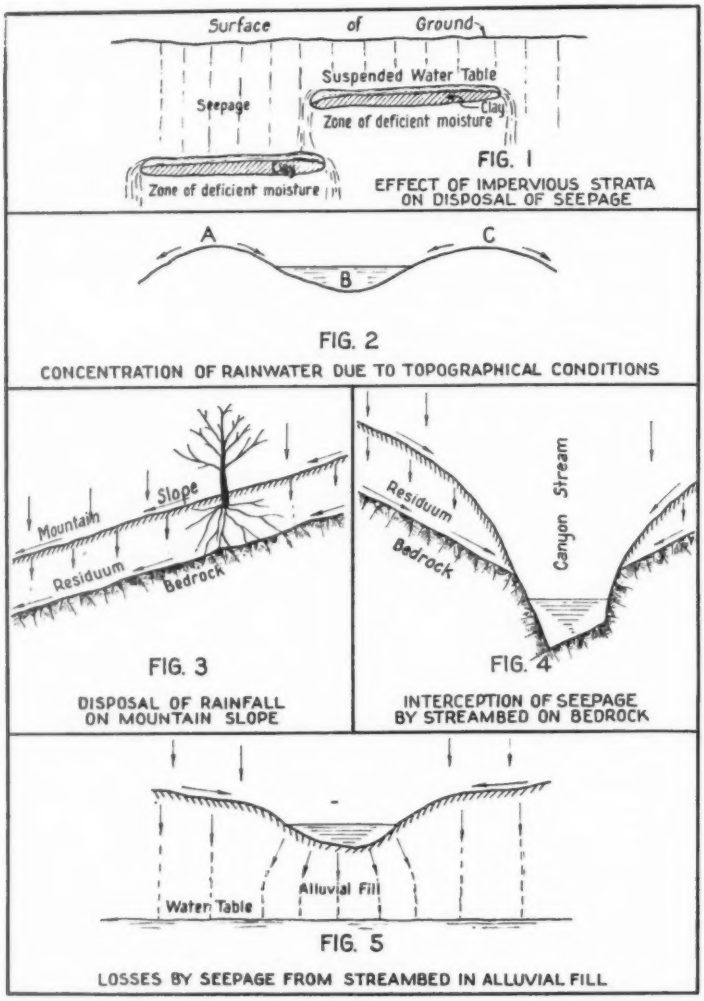


Plate 3

the gentle undulations which occur on an apparently true plane, or hogwallows and hummocky undulations as shown in Fig. 2, Plate 3. It is apparent that some of the rain falling on Points "A" and "C" will flow on the surface to the depression "B." A 3-in. rain may produce at "B" a depth of water of as much as 6 in. and a seepage greatly in excess of that at points "A" and "C." This concentration of rain water, therefore, induces a corresponding concentration of seepage and may be responsible, in part, for deep penetration when the seasonal rainfall uniformly absorbed is not sufficient to satisfy the moisture deficiency and evapotranspiration losses over large areas.

It is therefore concluded that the irregularities of topography, the heterogeneous character of alluvial soils and the actions of roots all tend to concentrate percolation along lines of least resistance and that a uniform wetting of the soil over large areas, even to is not readily ascertained and for this reason has, in the past, often been underestimated. The author has made extensive studies of this phenomenon, and his conclusions have been confirmed by the investigations of the engineers of the U. S. Department of Agriculture and State Department of Engineering.

In the San Bernardino Valley, above the lower Santa Ana Canyon, it has been determined that in certain years as much as 40 per cent of the total watercrop tributary to that valley is from rainfall on the valley floor, and that the contributions from this source exceed 200 acre feet per square mile.

It goes without further explanation that the gentle rains and light storms of dry years do not produce deep penetration to any extent. It is the rainfall of normal, and particularly of wet years with their heavy storms, that causes a substantial recharge of groundwater basins, which can be observed in the response of the water levels in wells. Where clay strata are extensive this response is lagging, but nevertheless ascertainable. The average proportion of recoverable voids in alluvial materials is about 15 per cent, a rise of the watertable by 1 ft. over an area of 1 square mile would indicate a recharge of 96 acre feet, equivalent to a depth of 1.8 surface inches of water.

Groundwater Basins.—Even the casual observer will notice that Southern California is dotted with thousands of wells, operated by pumping plants. Probably 75 per cent of the water supply of this country is derived from underground sources. The drilling of great numbers of wells has disclosed that the principal valleys, from the San Luis Rey River northerly to the Sierra Madre Mountains, are underlain by deep basins filled with alluvial materials. Having been laid down by flowing streams, these deposits are arranged irregularly, with kidneys of clay interlaced with lenses of gravel or sand. The latter are the water-bearing gravels, which, under favorable conditions, may carry as much as one-third of voids, or interstices, which are filled with water; this water, in turn, being subject to abstraction by means of wells and pumps. The valleys, or basins, are shown on Plate 4.

The entire San Fernando Valley is underlain by such a basin, as is the San Gabriel Valley, the Coastal Plain from Santa Monica down to Newport, the San Bernardino Valley, San Jacinto Valley, etc. The storage capacity of these basins is so enormous that the capacity of surface reservoirs, even of the size of the San Gabriel Canyon Reservoir, is but a fraction thereof. The recharge of these basins is effected by seepage from streams which cross the valleys, and from rain water seeping into the ground of the valley floor and beyond the roots of plant life, ultimately to reach the water-table. The groundwater, sometimes called the "underflow," percolates, as a rule, in the general direction of the surface stream. The rate of percolation is generally slow, ranging from 1 to 3 or 4 miles per year. Unless intercepted by barriers, the underflow will, in its natural course, reach the ocean underground.

A characteristic of most of these basins is the occurrence of underground barriers (dikes) or of lateral constrictions, or both, which interrupt the percolation of the groundwater streams. Taking, for example, the San Fernando Valley. At Van Nuys the valley has a width of 8 miles and a depth to bedrock of 1,000 ft. or more. At its outlet the valley is constricted from Burbank to Elysian Park by the approach from either side of the hill formation, narrowing the valley down to a width of ¾ mile. This is the Elysian Park "Narrows." There is, furthermore, an underground sandstone barrier which crosses the narrows at a depth of less than 200 ft. below the surface. The

combined effect of lateral constriction and barrier is to force the groundwater to the surface and to form the rising stream of the Los Angeles River. This river begins as a small stream in the vicinity of Van Nuys and gradually increases on its course toward the Narrows to a flow of 40 to 50 sec. ft., even in the summer months of a dry period. The Los Angeles River is therefore strictly a groundwater stream (except for its flood flow). In order to prevent pollution, the river is now drained by infiltration pipe lines, from whence it is conveyed to the city.

San Gabriel Valley extends from Pasadena to San Dimas, a distance of some 20 miles, and has a depth of alluvial fill of over 1,000 ft. At the Whittier Narrows the valley is constricted to a width of about two miles. The depth of fill at this point is about 480 ft. The effect of the "narrows" is a stream of rising water, beginning about at the Foothill Blvd. with a small stream and increasing, as the Mission St. bridge is approached, to a river carrying 60 to 120 sec. ft. This supply is diverted in a number of irrigation ditches.

The many narrows constricting our valleys, or basins, are indicated on Plate 4.

In the groundwater basins water will remain pure and potable for indefinite periods and is available for abstraction over long periods as it percolates from the mountains to the sea.

These groundwater basins present a natural and practical solution for the regulation of the otherwise erratic water supply of Southern California, making it possible to store water from a wet period into a dry period; in other words, permitting of a cyclic regulation of water supply. For this reason they are the fundamental physical factor which made possible the development of this country.

Too much emphasis cannot be placed on the economic importance of the deep gravel beds which underlie our valleys. The layman is inclined to lay stress on surface storage, believing that the water problem can be solved by the construction of surface reservoirs. The proper function of our flood control and conservation reservoirs is that of detaining floods. From such temporary storage and flood-waters may conveniently be carried on to the gravel deposits below the mouths of canyons and there caused to sink into the ground, to become a portion of the groundwater underlying our valleys. This method of conservation is also known as the spreading of flood-waters and is now practiced on practically all rivers and streams of Southern California.

Mr. William Mulholland, who might appropriately be called "The Father of Southern California Water Supply," many years ago realized the value of groundwater storage. When planning the Owens River Aqueduct, Mr. Mulholland took advantage of the underground possibilities of San Fernando Valley. In order to dispose of surplus aqueduct water, an irrigation system was planned for this valley and about 60,000 acres are now irrigated from this source. The seepage, or return water, from this irrigation, which reaches the groundwater basin underlying the valley, is estimated at about 25 per cent of the water applied. As a result of 10 to 12 years of irrigation, the groundwater levels in San Fernando Valley have risen in the face of a series of dry years and the flow of the Los Angeles River, which, at the end of a dry period as exists today, would flow from 40 to 50 sec. ft. at the Narrows, now discharges over 80 sec. ft., all of which is rising groundwater. This water is diverted by gravity for domestic use in Los Angeles. Thus a natural process, ingenious in its simplicity, has deliberately been taken advantage of and a gravity supply recovered at the gates of the city, which is conservatively estimated to be worth $3,000 per miner's inch, or, in round figures, $5,000,000.

Literature on Local Water Supply

Water Supply Papers of the U. S. G. S. by W. G. Mendenhall.

No. 137—Development of Underground Waters—Eastern Coastal Plain, Southern California.

No. 138—Development of Underground Waters—Central Coastal Plain, Southern California.

No. 139—Development of Underground Waters—Western Coastal Plain, Southern California.

No. 219—Groundwater and Irrigation Enterprises in the Foothill Belt of Southern California.

These papers, although written about 25 years ago, are still considered as presenting by far the best studies on Southern California groundwaters and are recommended to those interested in the subject.

Bulletin No. 5—Flow in California Streams. By State Department of Engineering, giving records of rainfall and stream runoff and estimated water supply of the State of California.

Bulletin No. 6—San Gabriel Investigations of State Department of Engineering, by Harold Conkling.

Proceedings, American Society of Civil Engineers, May, 1929.

Water Supply from Rainfall on Valley Floor, by A. L. Sonderegger, refers to Southern California conditions.

Acknowledgment.—The foregoing is a paper presented before the Water Supply Section at the 1929 Short Course in School of Citizenship and Public Administration held June 17-21, at the University of Southern California, Los Angeles.

Ohio Sewage Treatment Conference

The third annual Ohio Conference on Sewage Treatment was held Oct. 22 and 23 at Canton, O., with a registered attendance of 105. Two half-day sessions were held, with Charles C. Hommon, of Canton, presiding.

Subjects discussed were: The Canton Sewage Treatment Works, the Salem Sewage Treatment Works, the Ohio Sewer Rental Law, Sewage Disposal Litigation, Operating Small Sewage Treatment Works, and the Biological Oxygen Demand Test. Excellent motion pictures of the Salem Plant were presented.

Officers elected for the ensuing year were: Floyd G. Browne, Marion, chairman; T. C. Schaetzle, Akron, vice chairman; M. W. Tatlock, Dayton, secretary-treasurer; O. F. Schoepfle, Sandusky, member-at-large of the Executive Committee.
mittee.

A cordial invitation was received from Dayton to hold the 1930 conference in that city.

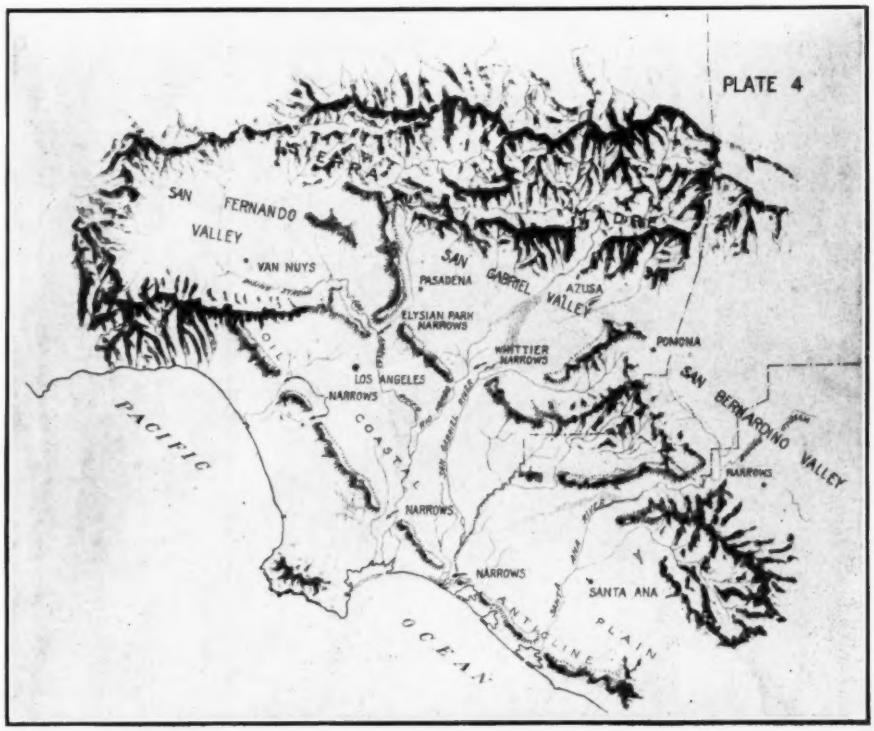


Plate 4

The Dewatering of Fine Screenings

Practice at Various Sewage Disposal Plants in Dewatering Screenings by Pressing and by Centrifuging

By KENNETH ALLEN

Sanitary Engineer, Board of Estimate and Apportionment, New York City

DISPOSAL of sewage screenings is not often a difficult problem in the case of a small installation and where there is land available where they can be buried in trenches, plowed under or merely covered, to prevent odors, fly breeding, etc.; but as the volume increases and land becomes more restricted it presents difficulties that may be very perplexing.

Character and Amount of Screenings.—The character and the amount of screenings per million gallons of sewage naturally varies between wide limits with the character of the sewage and the fineness of the screen. At one plant there will be found a large percentage of paper; at another fecal matter will predominate; at another vegetable kitchen wastes and at another sticks, twigs and leaves, depending on the season. With a normal domestic sewage the screenings will be composed largely of paper and feces, both of which will diminish in amount in stale sewage by disintegration.

In general the fine screenings from normal city sewage usually amount to 15 to 25 cu. ft. per m.g. sewage, weigh 50 to 60 lb. per cu. ft. and contain 75 to 90 per cent water and 80 to 90 per cent volatile matter (dry basis). They are generally so wet as to be "sloppy" but can be handled with a spade.

They are difficult to burn when containing over 70 to 75 per cent moisture and the greater the reduction in this percentage the longer they may be stored without giving off objectionable odors and the more readily is combustion effected.

Methods of Disposal.—Screenings can be disposed of with due regard to sanitation:

(a) By burying in trenches prepared in advance.

(b) By mixing and disposing of with the city garbage.

(c) By digesting, spreading and plowing under.

(d) By dewatering and burying, plowing under or burning.

Burying, in the case of all but small plants, is open to the objection that it requires considerable land and manual labor.

Disposal with garbage is often the most practicable method, but where it is to be incinerated the moisture content demands a thorough mixing with sufficient added combustible rubbish.

Digested screenings are relatively inoffensive, and although containing perhaps 95 per cent moisture, may be disposed of by drying on beds to about 70 per cent moisture, by spreading on the land and plowing under or merely used as fill.

At the Milwaukee works experiments in digesting screenings have been carried on for over a year and others, on screenings from Plainfield, have been made by Dr. Rudolfs at the New Jersey State Agricultural Experiment Station, both with the possibility of success if carried out under proper control. Careful, competent supervision appears to be necessary to bring about active and inoffensive decomposition, involving the proper seeding, temperature and pH control. Moreover, suitable provision for final disposal by drying or otherwise, involving additional land, must be made and in a built-up section this may not be practical. For these reasons some method of rapid preliminary dewatering to not over 70 per cent moisture seems desirable in the majority of cases. There are two general methods of accomplishing this: (1) by pressing, and (2) by centrifuging.

Methods of Dewatering. — Coarse screenings from racks, cages, etc., have been pressed at a number of plants for a good many years. The presses have usually been of the "cider" type, operated by hand or by hydraulic power.

At Washington a hydraulic press of this type, 24 in. in diameter, was installed in 1906, operating under a pressure of 105 to 115 lb. per sq. in., requiring two men for each 8-hour shift. It is understood that this press has stood up well under service and given good satisfaction. In the fiscal year, ending June 30, 1929, 1,905,839 lb. screenings were pressed, varying from 4,153 to 7,974 lb. and averaging 5,221 lb. per day, the weights being of the dewatered material, which contained about 85 per cent moisture.

Favorable results were secured at Washington where coarse screenings were put through a hydraulic press and then burned in a small Decarie incinerator used as a hot water heater for the building. Their volume was reduced about 60 per cent in the press. About three pressings were made per hour during dry weather conditions of flow, when the weight of pressed screenings per 24 hours varied from 2,800 to 3,100 lb. About 200 lb. coal was required to start the fire at the beginning of each shift, or 0.2 lb. coal per lb. pressed screenings.

A similar press, but operated by both steam and hydraulic power, was installed at Boston at the Calf Pasture pumping station in 1912. This required the attention of but one man while handling one to four charges per hour. The dewatered material was burned without difficulty. The press here is understood to have proved unsatisfactory.

At the Ward Street pumping station a steam-operated press, 24 in. by 18 in. diameter, has more recently been installed. The screenings, dewatered to 65 per cent to 75 per cent moisture, are burned under the boilers of the plant.* A press of this kind, operated by steam or hydraulic power, will handle about 500 cu. ft. wet screenings per day and cost in the neighborhood of $3,000.

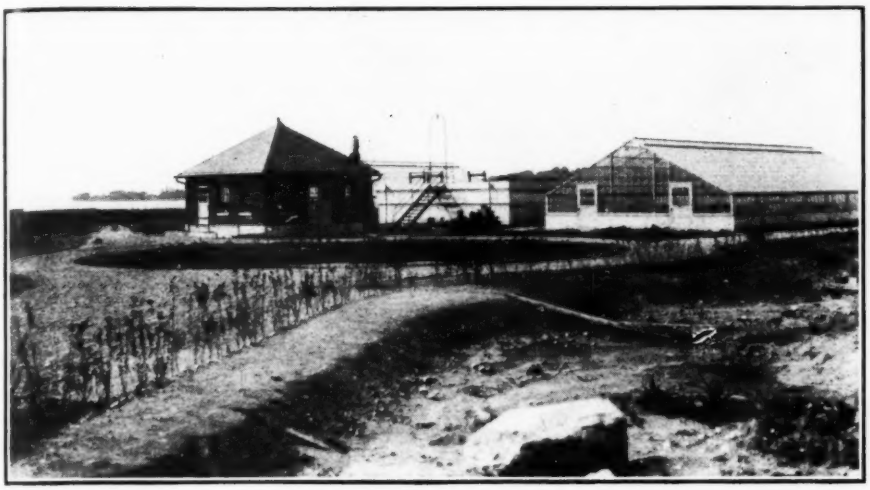
Dewatering Fine Screenings.—There has been little experience as yet in the dewatering of fine screenings. With the larger amount of fine organic material their water content is probably given up somewhat less readily than from coarse screenings but from what has already been accomplished and with the more extensive experience in dewatering sludge the question of dewatering fine screenings may be considered a matter of detail.

Fine screenings have been dewatered for several years by pressing in the Borough of Queens at three plants in the vicinity of Flushing Bay. The screenings are then burned in small oil-burning "incinerites." A test of one of these, located at Corona, was made in 1920. The screenings were placed in the hand press and left to drain for 19 hours when they were removed and burned. The 2.78 cu. ft. pressed screenings contained 69 per cent moisture, weighed 52.0 lb. per cu. ft. and were consumed in three hours with a loss of 93 per cent weight, for which 0.018 gal. of oil was required per pound dewatered screenings. By care in firing these small installations are quite satisfactory.

In 1914 the city of Baltimore installed a 24-in. press similar to that at the Calf Pasture pumping station at Boston. Pressures here were carried as high as 170 lb. per sq. in. Four-and-one-half baskets were charged per hour, requiring the attention of two men. In spite of the pressures used the moisture in the product was too great for easy burning, possibly due to the high rate of operation.

In 1921 three more presses of the same type were installed at the main

*If they are so sloppy as to be forced through the perforations of the basket a small quantity of shavings are added to absorb the excess moisture. Two men are required for operation on each shift.



Sewage Treatment Plant at Oyster Bay, N. Y.

sewage pumping station. Four pressings per hour can be made with these if necessary. By measurement about 3 cu. ft. dewatered screenings were produced from each of 48 pressings per day from a sewage flow of 25 m.g. As these wighed 60 lb. per cu. ft., the total output amounted to about 8,000 lb. per day. To burn this required about 1,600 lb. of coal.

In 1926 C. E. Keefer made tests in pressing the screenings at the Eastern Avenue sewage pumping station.†

Average Results

	Unpressed Screenings	Pressed Screenings
Cubic feet per m.g. sewage	7.75	4.04
Pounds per cu. ft.	60.17	50.03
Per cent moisture	86.45	72.19
Coal used for incineration:		
Lb. per cu. ft. screenings	.....	11.07
Per cent reduction in volume by pressing	.....	47.85

The estimated cost of a pressing and incinerating plant to dispose of the screenings at this station was:

For: Building		$3,540
Incinerator, chimney, etc.		1,800
Press		3,600
Total		$8,940

and the annual cost was:

For: Fixed charges		$ 894
Operation:		
Coal (97 tons)	$626	
Power for press	10	
Removal of ashes	20	
		656
Total		$1,550

As a result of these tests it was decided to continue this method of disposal.

Experiments in pressing screenings were made by Mr. Keefer at the Back River disposal plant, Baltimore, in 1927, using a cider-type press operated by steam under 175 lb. per sq. in. pressure. The press was manufactured by the Coffin Valve Co., and cost, in 1919, $2,785. The screenings averaged 7.75 cu. ft. per m.g. sewage and contained about 86 per cent moisture, which was reduced to 72 per cent, with a reduction of 48 per cent in volume by the operation.

†Proc. Am. Soc. C.S., Sept., 1929. The flow handled at this station averaged 25 m.g.d. in 1925.

Dallas, Texas, installed a 19-in. hydraulic press in 1915. With a pressure of 60 lb. per sq. in., four to eight baskets of screenings were pressed per 24 hours sufficiently to burn readily under a boiler. The only attention required was that of the boiler room helper. The operation of this press is said to have been satisfactory.

At Milwaukee it was attempted to press the fine screenings in a Berrigan press. This proved quite feasible, but was finally abandoned as too costly.

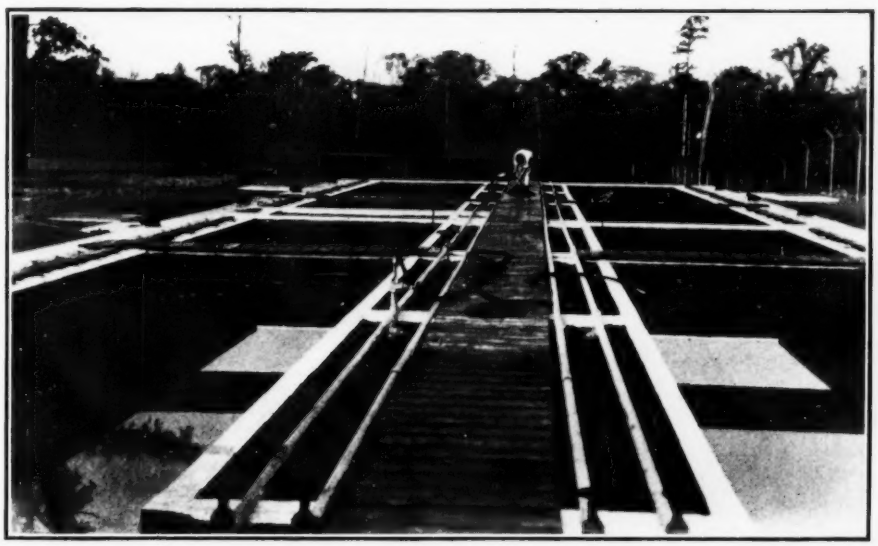
A plant designed by Metcalf & Eddy is now being installed at Dayton, Ohio, in which the screenings from a Dorrco screen with ⅛-in. slots will be dewatered in presses made by the Hydraulic Press Mfg. Co. and then burned in a specially designed incinerator. It is estimated that the moisture content of fine screenings from 26 m.g.d. sewage will be reduced from 85 per cent to 65 per cent by placing them in slotted baskets and compressing under a hydraulic plunger. The 230 cu. ft. dewatered material produced per day will then be burned together with screenings from a 4-in. rack 80 per cent moisture and skimmings 75 per cent moisture.

From the foregoing it is safe to conclude that normal screenings, whether from coarse or fine screens, may be dewatered in a press of proper design to such an extent as to be disposed of by burning under boilers, in a garbage incinerator or in an incinerator specially designed for the purpose, with little additional fuel. At Baltimore the life of a press of the cider type has been found to be about eight years. These are generally of 24-in. or 26-in. diameter, operated under a pressure of 150 lb. per sq. in. and compress the screenings to half their original volume.

Experience with wet screenings has not been so convincing, although these are burned in a few places.

At Miami, Fla., about 40 cu. ft. per day of screenings, averaging 50 lb. per cu. ft., are successfully disposed of by incineration in a Nye odorless incinerator without additional fuel and without odor after pressing under a dead weight of 500 lb. They are stored in covered garbage cans until night, when they are hauled to the incinerator. This is located in a residential section.

The fine screenings at Rye, N. Y., Long Beach, Calif., and coarse screenings at Canton, O., are disposed of without pressing; at Rye in an adjacent Morse-Boulger incinerator with the village garbage, and at Long Beach and Canton in incinerators designed for the plant. At Long Beach 47.7 cu. ft. screenings per day about 80 per cent moisture are successfully burned in a dutch-oven furnace with 21,300 cu. ft. natural gas. At Canton about 27 cu. ft. screenings of similar water content are incinerated daily after an hour's draining in perforated cans, together with an average of about five dead animals, with the use of about ten tons of coal a month. At the Jamaica plant, Borough of Queens, the 5 cu. ft. fine screenings per m.g. from a flow of about 10 m.g.d. of sewage contained 87 per cent mois-



View of Portion of Sewage Disposal Plant at Teaneck, N. J.

ture. The attempt to dispose of these wet screenings with the city refuse in a 150-ton incinerator did not prove satisfactory.

Centrifuging.—There is no reason to suppose that screenings as well as sludge may not be dewatered by centrifuging. The smaller volume of foul drainage liquor would present a less serious problem and it is quite possible that a less expensive type of centrifuge than the Bescoter-Meer might answer the purpose. Very little has been attempted in this line but as the number of screening installations increases it is possible that this method of dewatering may be found practicable.

At Reading, Pa., screenings from a fine-mesh "Weand" screen were placed in canvas bags and dewatered by a centrifugal "hydro-extractor," about 6-in. diameter by 3 ft. 6 in. high, which reduced the moisture in a charge of 500 lb. from 85-90 per cent to 61-73 per cent moisture in eight minutes. Its weight was reduced from 65-70 lb. to 30-35 lb. per cu. ft. by the process, when it contained about 72 per cent volatile matter. It was then burned under the boiler at the plant. The plant was rebuilt some years ago and the screen abandoned.

Experiments were conducted by George G. Gascoigne at Cleveland in which about 1¼ tons of fine screenings, 85 per cent moisture, after a brief period of draining, were placed in burlap bags and dewatered in a "Laundryette" centrifuge. The moisture was reduced to 65 per cent and screenings burned in a small "Kewanee" incinerator by adding about 25 per cent of coal by weight. The incinerator had a nominal capacity of 300 lb. screenings per hour, 90 per cent moisture. Some smoke and odor were given off, but no complaints were recorded.

Screenings were burned under a "Sims" boiler for a while at the Easterly Works several years ago after dewatering in a "Troy" centrifuge, but some odor resulted and the practice has been given up.

At Baltimore tests of a sludge centrifuge made by the Hanomag Co. of Germany indicated that the passages were too small to function properly with screenings.

Centrifuges, belt-driven or direct-connected, are on the market that may prove adapted to service of this nature. They generally consist of a perforated basket, 30-in. to 40-in. in diameter, in which the screenings are placed and which rotates at speeds as high as 900 r.p.m., the drainage liquor being let off by a pipe. To unload, the basket is raised, moved to one side and dumped by rotation on trunnions. In one type there is a counterbalanced "unloader" which, by a slow rotation, scrapes the cake gradually from the top down. The material thus loosened falls through a port in the centre of the bottom, provided with a cone valve, to a conveyor or truck.

The first cost of a 40-in. centrifuge is about the same as that of a press. Operation is largely automatic, requiring but one man, but a fair comparison with presses, which have more often been used, cannot be made at this time.

View of Portion of Northeast Sewage Disposal Plant, Philadelphia, Pa.

Amount and Character of Fine Screenings

Location	Opening	Screenings Per M.G. Cu. Ft.	Lb.	Per Cu. Ft. Lb.	Moisture Per Cent	Volatile Per Cent
Brooklyn, N. Y.—						
26th Ward	5/64 in.	8.8	.....	.....	82	83
26th Ward	1/16 in.	7.5	.....	.....	80	81
26th Ward	3/64 in.	5.7	.....	.....	86.8	93.5
26th Ward	1/32 in.	5.2	.....	.....	77	68
Los Angeles, Cal.—						
N. Hyperion	1/16 in.	16.5	.....	.....	87	....
Long Beach, Cal.	1/32 in.	27	1,810	67	87	....
Remodelled	1/16 in.	.....	2,485	.....	75.85	....
Milwaukee, Wis.	3/32 in.	7—8	315	.....	86—90	....
Experimental	¼ in.	21	985	47	88	....
Pasadena, Cal.	1/16 in.	30	.....	.....	88	....
Plainfield, N. J.	1/16 in.	15.8	.....	.....	89	....
Plainfield, N. J.	¼ in.	5.67	261	46	84	....
New York—						
Dyckman St.	3/64 in.	27.1	1,449	53.4	78	88
Dyckman St.	1/16 in.	18.4	1,040	56.5	82	91
New Britain, Conn.	1/16 in.	30	2,020	67.3	81	....
Reading, Pa.	1/30 in.—1/36 in.	31	.....	.....	89.5	....
Reading, Pa.	.014 in.	25	1,500	60	89 5	73
Brockton, Mass.	.0214 in.	38	1,990	52	71	....
Guildford, Eng.	.25 in.	9.3	370	40	75	....
Burton, Eng.	.38 in.	9.5	380	40	75	....
Bromberg, Poland	.08 in.	13.4	870	65	85	....
Leeds, Eng.	.125 in.	36	1,080	30	....	....
Leipsig, Ger.	.31 in.	2	80	40	75	....
Columbus, Ohio	.375 in.	4.6	300	65	....	....
Croydon, Eng.	.4 in.	14.6	583	40	75	....
Frankfort, Ger.	.4 in.	15.8	635	40	....	....
Elberfield, Ger.	.4 in.	21.6	865	40	70	....
Göttingen, Ger.	.4 in.	14.7	337	23	83	....
Dresden, Ger.	.08 in.	26.2	.....	.....	84	....
Strassburg, France	.10 in.	43	.....	.....	89.3	....
Tier, Ger.	.10 in.	8.6	.....	.....	55	....
Temesvar, Roumania	.12 in.	35.1	.....	.....	65	....
Keansburg, N. J.	3/64 in.	44	.....	60	....	....
Cleveland, Ohio	1/50 in.	.....	858	.....	94	73
Experimental	1/80 in.	.....	674	.....	90	64
Experimental	1/120 in.	.....	682	.....	86	72

Conclusions.—Dewatering screenings to an extent when they may be burned without difficulty may be accomplished by pressing and probably by centrifuging. With the increasing number of screening plants and a growing insistence on hygienic conditions this method for their final disposal seems likely to develop in the future.

In conclusion the author desires to acknowledge as the source of much valuable information that he has freely drawn upon in the preparation of this paper, the following gentlemen: Major D. A. Davison, U. S. A., also Robert Cramer, George B. Gascoigne, Charles C. Hommon, J. E. Jewett, F. B. Jones, C. E. Keefer, W. T. Knowlton, F. A. Marston, Langdon Pearse, Asa E. Phillips, W. M. Pratt, Harry L. Shaner, Ralph Van Duyne and W. W. Young. Thanks are also due the several manufacturers of dewatering machinery and incinerators for details concerning their

devices that have been kindly furnished.

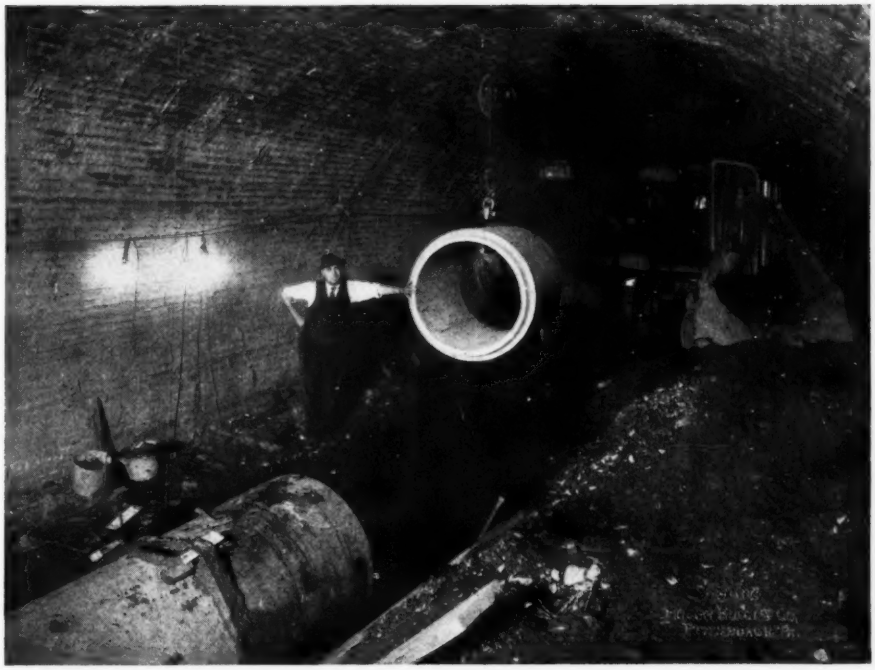
The application of devices for filtering or straining slimes or sludges has not been discussed in this paper, for although some of them may prove valuable for the dewatering of screenings reliable information as to results obtained has not yet been obtained. In one experiment, however, by Filtration Engineers, Inc., screenings conditioned with lime were dewatered from about 90 per cent to 66 per cent moisture on a vacuum filter.

Acknowledgment.—The foregoing paper was presented Oct. 16 at the 35th Annual Convention of the American Society for Municipal Improvements.

Trencher Shovel Digs Sewer in Cramped Quarters

A construction job which afforded more than the ordinary amount of excitement was that recently executed by a crew of Ralph Bucci & Co., Pittsburgh sewer contractors, consisting of digging trench and setting pipe in a shallow, semi-round sewer tunnel under the plant of the Homestead Steel Works, Homestead, Pa. Steaming hot drainage water flows directly into the tunnel from the steel mill.

A sanitary sewer of 36-in. reinforced-concrete pipe was laid through the entire length of the 1,000-ft. tunnel. The trench for the pipe was dug to a depth of 4 ft. The contractors took the job after comparing the 13-ft. headroom in the tunnel with the clearance height of their Byers ½-yd. trencher shovel—11 ft. 2 in. It was found that the best way to handle the job was to use the trencher shovel boom, taking off the dipper and arm and substituting a ½-yd. clam-shell bucket. The bucket was replaced with a hairpin hook for pipe setting.



Laying 36-In. Reinforced-Concrete Pipe With Trencher Shovel Under Homestead Steel Works

Under the difficult conditions existing in the tunnel, the shovel was able to dig in excess of 300 cu. yd. a day, it is stated. However, only 80 lin. ft. of trench was excavated at a time; this length of trench was dug and the pipe set in 10 hours. Pipe laying was delayed because all joints in a section had to be sealed with tar and allowed to set before the next section was begun.

The possibility of an added thrill to the workers was introduced when it was learned that the water in the tunnel sometimes rises to a height of 6 ft. during heavy storms. Throughout the work, however, fair weather prevailed, and the members of the crew had nothing more than the normal flow to contend with.

Trenching With Limited Clearance Within Sewer Tunnel Under Steel Plant at Homestead, Pa.

Water Company Spends One Third of Every Revenue Dollar for Taxes

The total amount paid for salaries and wages last year by the Hackensack Water Company, serving fifty-one towns and cities in Bergen and North Hudson Counties, New Jersey, was $1,051,318.65, according to statistics prepared by the company's accounting department.

Taxes for the year amounted to $842,144.02. Of every dollar of revenue, 30½ ct. was paid out for taxes.

More than 50 per cent of the total revenue of the company is paid out in taxes and wages. Practically all of this amount, in addition to expenditures for materials, supplies, maintenance and repairs, is spent in the territory served by the company.

Coal used at New Milford and New Durham cost $100,103. To haul this coal, eleven freight trains of fifty cars each would be required. If placed end to end, the trains would reach over five miles.

The expense of repairing buildings was $22,604. Sufficient money was spent on postage to mail a letter to every man, woman and child in the city of Newark.

More than 1,000 different types and sizes of material are carried in the company's storerooms. During the year more than 3,500 purchase orders and 6,000 voucher checks were drawn. Cards in the company's files showing detailed costs of service installations number over 60,000.

Purchased Power for Pumping Station Operation

By T. R. HUGHES

Mechanical Engineer, American Water Works & Electric Co., New York, N. Y.

WITH the development in the last five years of central station power plants, generating electric energy at high efficiencies, and the increase in reliability of this power, due to the interconnection of the various transmission systems, the advantages of using purchased power for the operation of small pumping stations are becoming more significant. These advantages are being generally realized now. Operation with purchased power means a minimum of investment, a minimum of labor cost and a relatively high operating efficiency for small units. Compensating for these economies the cost of energy is usually somewhat higher than the cost of coal.

Comparison of Operating Costs.—To gain some picture of the size at which the steam plant no longer becomes the most economical for operation, I have plotted a curve in Fig. 1. This shows the total cost of pumping station operation, fuel, operating labor, maintenance and miscellaneous supplies, per water horse-power hour developed compared with the average water horse-power load on the plant. The term "water horse-power" is, of course, the brake horse-power required to drive a pump of 100 per cent efficiency. The cost of pumping per water horse-power hour is a particularly significant figure, both because it is a unit of work and because it may be readily visualized when it is considered that the overall efficiency of the average motor-driven pumping unit is in the neighborhood of 75 per cent. Therefore, one water horse-power hour may be roughly considered as equivalent to 1 kw. h.

The figures shown are all (except No. 14 which represents a carefully prepared estimate) taken from operating records of plants actually in operation and represent results being obtained. The only correction made to them was to reduce coal to $3.50 per ton. They are all fully comparable. The figures represent, with the exception of No. 13, plants operating reciprocating pumps, water being measured by plunger displacement. Actual water measured would be less and cost per water horse-power hour more than shown. With any centrifugal pump where water is metered economy will be correspondingly increased.

In Fig. 1 it will be seen that, with a plant as large as 650 water horse-power, the cost per water horse-power hour is ¾ ct. With a plant of 25 water horse-power average load, the cost of pumping is 4.8 ct. Both of the plants considered are operated more economically by purchased power. There are very few rates for energy at less than 1 ct. per kilowatt hour. To this must be added labor and miscellaneous operating costs. On the other hand with an average load of 25 water horse-power, it is probable that power could be purchased for about 1½ ct. Labor would be less than that required

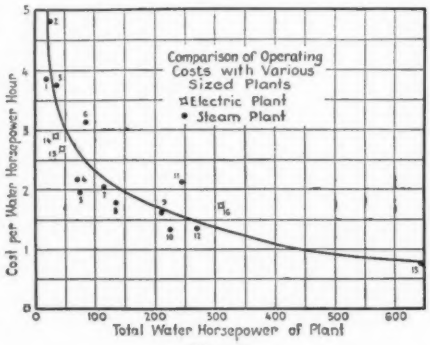


Fig. 1

to operate a steam plant, and it would appear probable that this station could be operated more economically with purchased power. From a point of view of operating cost along, it would seem probable that electricity would prove more economical on the plants smaller than 100 or 200 water horse-power.

Two points are also shown in Fig. 1 which represent the operating cost of plants operated on purchased power. The electric plant of 44 horse-power size, No. 15, is operating more cheaply than the steam plant of that size would. This means that not only is the cost of operation of this plant less than the cost of operation of a steam plant, but also considerable saving has been made in the investment required to build the plant. The 310 h. p. plant, No. 16, operated by purchased power, costs somewhat more to operate than one of equivalent size operated by steam. This, therefore, is approaching the point of demarcation between the economical electric and the economical steam plant.

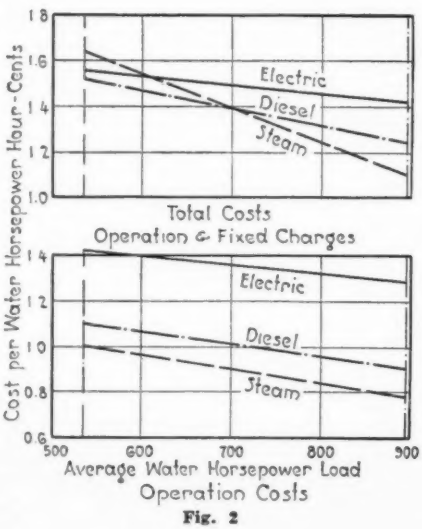


Fig. 2

Comparative Costs for Operation and Fixed Charges.—Figure 2 shows comparative costs for both operation and fixed charges of various types of plants. It is a study of a plant starting with a load of 535 and growing to one with a load of 890 water horse-power; that is, it would be a plant pumping an average of 15 m.g.d. against a head of 203 ft. and would grow to a plant of 25 m.g.d. against a head of 203 ft. In this study steam, Diesel engines and purchased power were all considered. The investment required under each of these heads was very carefully estimated and the operating costs are those which can be achieved. The coal is at $3.50 a ton as was the case in Fig. 1. Diesel engine fuel is at 6 ct. a gallon and electricity 1 ct. per kilowatt hour. Fixed charges on the investment required in each case were taken at 12 per cent for taxes, depreciation and interest. In the upper curve it will be seen that for the smaller plant purchased power is almost as cheap, considering operation and fixed charges, as the Diesel engine plant, even when the load is as great as 535 water horse-power. The lower curve showing operating cost shows that steam is considerably cheaper for each case. The investment in the small steam plant, however, is so large as to throw this out of line and makes the total cost greater than of either electricity or Diesel power. Purchased power is probably the cheapest for plants smaller than 400 h. p. Diesel engines may be the most economical source of power for plants with a load of from about 400 to 600 water horse-power.

When Fig. 2 was prepared, it was not realized that, in the case of the particular plant considered, the apparent dividing line between all three types of equipment would be covered. It was merely a coincidence that due to the loads chosen this was the case. The figures, unfortunately, all represent estimates. These curves and generalizations drawn from them are made, not with an idea of laying down any hard and fast rule, and saying to the water works designer that he can always save money, if building a plant whose average load will be 200 water horse-power, by operating it on purchased power, or that he will always save money by building a 400 water horse-power plant and operating it by Diesel engines. The curves can only be used to draw certain general conclusions and point the direction in which the most careful study should be made for plants of various sizes.

The plant studied in Fig. 2 was one which has a relatively high load factor. A plant which has a very low load factor would probably show greater relative economics due to purchased power than the one considered here due to saving banking losses and the like.

Where a plant pumps into a large reservoir with constant load and ample reserve, all the advantages are in favor of purchased energy. In the case of the very small plant with some storage in the system, automatic operation may be used and almost all labor eliminated. In some cases it may prove desirable partially to electrify the plant. Where some existing steam equipment is economical this may be the case, either using the steam for base load or for peaks as may best suit the conditions. The partial electrification of a plant has the double advantage of reducing the cost of duplication of electric power, should it be necessary, to a minimum and also holding a convenient club over the head of the power company to keep them from raising the rates after they think they have secured their customer, since it is always easy to go back to the steam plant if they prove unruly.

The most difficult condition under which purchased power may prove economical is the case of an existing steam operated plant of small size which is to be converted to an electric plant. The only excuse for the electrification is that the total cost of the electrified plant, both for operation and fixed charges on the equipment required for electrification, will be less than the cost of operation of the steam plant. It may be easy to show that the cost of operation of a plant run on purchased power is cheaper than one run on steam power. When, however, we have to pay fixed charges on new equipment out of this saving, it very rapidly evaporates. Although the power companies frequently point out the large savings which may be effected by the electrification, it is frequently difficult to justify this procedure when one must make considerable investment.

The maintaining of a high operating efficiency when the energy cost for the plant is high is important. If a plant is being operated on purchased power, it is highly important that care be taken in the selection of pumping units in order that the efficiency may be as high as possible during normal operation.

Operating Efficiencies.—One installation from which we have very good data on operating results shows that for 12 months the average operating efficiency of unit No. 1 in this plant was 66.7 per cent. Under test conditions and at exactly the right head this unit had an efficiency of slightly more than 70 per cent. It is a constant speed unit and the head varies as much as 10 per cent above and below the average which, of course, cuts into the operating efficiency. Unit No. 2 in this plant had an average efficiency of 72.7 per cent for 12 months with a test efficiency of about 77 per cent. Unit No. 2 is operated by a variable speed motor, and the efficiency, of course, is low at any time at which the motor is run below full speed. These two units pump into a system which has very little storage and, therefore, the pumpage rate has to follow the demand closely and the system is subject to wide variations in load. In spite of the exacting load conditions and with only two units installed, the pumps operated within 6 per cent of their original guarantees. The figures are based on average heads obtained and, therefore, are not absolutely correct.

In another plant at which four units are operated, the average efficiency of the four units on test is 64 per cent. The average operating efficiency for 12 months of these four units is 63.7 per cent. This is a direct system. The four units are relatively small, and all are constant speed units. They are operated close to their point of test efficiency at all times.

A third plant considerably larger than either of these two just spoken of, pumps into rather large reservoirs and the pumpage rate is practically constant from day to day. This plant is operated on purchased power, and the average operating efficiency for 12 months is 83.6 per cent. Tests on the two units operated, both of them variable speed units, give an average efficiency of 82 per cent. The efficiency of 83.6 per cent is hardly reasonable. The variable in measuring average operating efficiency and test efficiency is the head against which the units operate, which varies considerably. The only conclusion that can be drawn from these figures is that the operating efficiencies of these motor driven pumps, which deliver water into a reservoir at a very nearly constant rate, is very near the best test efficiencies of the units. Of the two units in this plant, one has a capacity of 14 and the other a 21 m.g.d. They, therefore, may operate very near to the designed conditions at all times as the one of the most suitable size may be operated all the time.

These last two cases cited illustrate the desirability, when installing several units at a station, of not getting two or three units of the same capacity. A little care in selecting the capacities of the units will result in being able to operate at full load at all times and with consequent high efficiency. When more than one unit is installed, with a change in load, one pump may be readily shut down and another started up and the most suitable unit always kept in operation.

With the interconnection of transmission systems, electric power is quite reliable, but some duplication is usually necessary. Judging by the experience we have had in two particular cases, it would seem probable that the duplication need be for use only for a short time. One plant supplied by a transmission line, 7 miles long, from the nearest sub-station, and that substation supplied by only one high voltage line, 25 or 30 miles long, has been subject to no extended outages. They have a number of times had power off for 15 minutes to an hour.

Another plant supplied by one transmission line, 1 mile long from the nearest sub-station, which does not supply any other consumers, and the substation supplied with power from a single high tension line, 15 to 20 miles long, has suffered from only occasional outages of from 15 to 20 minutes within the last two years. It would seem probable that, in supplying duplication for a plant operated on purchased power, unless the conditions were such as to make interferences likely, an outage of more than two hours would not be likely to occur.

Summary.—Summarizing:

1. We may say that a pumping station operated from purchased power will on operating cost alone be cheaper than with steam for plants whose load is from 100 to 200 water horse-power and below, the advantages of purchased power being greater as the plant becomes smaller.

2. When fixed charges as well as operating costs are considered, purchased power will probably be the cheapest plant to build and operate where the load does not exceed about 400 water horse-power.

3. For operation of a plant with purchased power, care should be taken to select units which will operate very near their peak efficiencies at all times. It is probable that for a direct system the average operating efficiency of the unit may be about 95 per cent of the guaranteed efficiencies provided suitable equipment is installed.

4. Purchased power with the present interconnection of electric systems is quite dependable and except for unusual conditions outages of more than 2 hours should not be expected.

Acknowledgment.—The above paper was presented before the New York Section of the American Water Works Association and is reprinted here from the October Journal of the Association.

Water Works and Sewerage in Wisconsin.—Figures in 1929 Waterworks, Sewerage and Refuse Code of the State Board of Health of Wisconsin show that 282 municipalities in that state have public water supplies and 211 have public sewerage. Of the latter 127 are not provided with any form of treatment. There are 10 municipalities in the state with less than 500 population (1920 census) that have both water works and sewerage and 29 that have water works only. Over one half the municipalities between 1,000 and 1,500 population have both water works and sewerage and about one quarter have water works only. All cities over 2,000 population except one are equipped with both water works and sewerage.

State Forbids 500 ft. San Gabriel Dam

Report of Consulting Board of Geologists and Engineers on Site for Los Angeles County, Calif., Flood Control Structure

As a result of a report by a consulting board of geologists and engineers, Edward Hyatt, State Engineer of California, has denied the application of the Los Angeles County Flood Control District for authority to construct the San Gabriel dam in the San Gabriel river, 30 miles northeast of Los Angeles, Calif. In the report of the state engineer the consulting board declared that the proposed San Gabriel dam, a gravity concrete structure, 500 ft. high and capable of storing 240,000 acre feet of water, could not be built safely on the foundation existing at "the forks" site. However, the board expresses the opinion that a dam of flexible type, such as an earth and rock fill structure of conservative proportions, could be built safely at "the forks" site.

Disapproval by the state of the application, according to the state engineer, is without prejudice to the right of the county to file any new application for a dam at this or any other site that the county may wish to submit. It means simply that the state finds that a 500-ft. concrete dam if built on the foundations at this location would not be safe and this particular application is disapproved.

The consulting board consisted of Charles P. Berkey, geologist, of Columbia University, New York; George D. Louderback, Geologist at the University of California, Berkeley; Ira A. Williams, Consulting Geologist, Portland, Ore.; G. A. Elliott, Engineer of the Spring Valley Water Co., San Francisco; M. C. Hinderlider, Colorado State Engineer, and J. L. Savage, Chief Designing Engineer of the U. S. Bureau of Reclamation.

The consulting board's report, follows in part:

Each Dam Site a Problem.—The natural conditions in the San Gabriel Mountains are much more complex than is usually appreciated. Although certain general geologic features prevail, each dam site is a problem in itself and demands special study and handling.

The rocks of this site and vicinity are ancient crystalline types, including granitic and dioritic gneisses and occasional schists, all cut by variety of igneous intrusions, including granite, aplite, diorite, dibase, basalt and porphyrites. The result is a crystalline complex, whose detailed history is long and involved, but whose character and quality would be eminently satisfactory for any engineering structure if the rocks had not undergone deformation and decay.

The rock complex is cut through in every direction by faults and slips and crush-zones that have separated the mass into blocks of varied size and shape, most of which are comparatively small and roughly wedge-shaped or lenticular. No portion of this site or immediate adjacent ground is free from this condition. In addition, each individual block formed by these fault movements is internally broken, and mol fractured and jointed, in such manner that most of the material separates readily into small pieces and there are no extensive bodies of solid rock.

Rock in Faulted and Crushed Condition.—The original structural make-up of the rock formation, with its many different types of varying individual resistance to crushing, has favored the development of internal differential movement, and this has resulted in the mashed and jammed appearance that characterizes the rocks of this site. The rock was not originally weak, but was unevenly resistant and the forces producing movement have been powerful enough to overcome the resistance of the whole mass.

It is generally conceded that the San Gabriel Mountain mass has been thrust up, and that in addition to very large movements on the faults along the boundaries of the mountain block, there are a few zones of major movement cutting through it. One of these zones takes an east-west course and has determined the alignment of the east and west branches of San Gabriel river. Another such zone apparently runs nearly north and south and has been followed by the river in its course below the forks. The forks is thus in the junction area of the two fault zones. The unusually numerous fractures at this locality seem to be consistent with this larger structural relation.

In addition to the faulted and crushed condition of the rock, much of it, especially that on the upper slopes of the canyon sides and along the principal movement planes and crush zones, is extensively disintegrated and decayed. The crushed and pulverized rock along the fault breaks is often transformed into clay gouge. Some of it is so soft that when moist it can be molded with the hand.

Unfavorable Controlling Factors.—The surface materials are weathered into soil. By the same process some of the unbroken material beneath is altered or rotted to such condition that it can be broken easily with the fingers. Along the more fractured zones decay extends as deep as explorations have gone. This altered condition, together with the excessively broken character of the ground and the smoothed and lubricated movement planes, are controlling factors with respect to any very large engineering structure.

Observation shows that the crush zones and movement planes and slips occur in all portions of the site, as well as beyond the site proper in every direction. Drilling data prove that the same kinds of weaknesses, especially the slips and faults and broken rock and gouge, extend also beneath the site to as deep as explorations have gone.

Landslides are common on the canyon slopes. These doubtless represent the slumping of individual blocks or groups of blocks, separated from each other by slip planes, when they are weakened by progressive undercutting of a stream, lubrication due to access of water and downward extent of weathering. Relatively recent slides have occurred at the site and at several places in the vicinity.

Where the rock is harder or more uniform than the average, the individual fault blocks are larger, the internal slips and crushes are less numerous and the accompanying decay correspondingly less extensive. This is the reason for the less broken appearance of the east abutment than that of the west abutment, although there are no different kinds of effects or any other principles represented.

Even the floor of the canyon is not free from this condition. A badly broken zone lies beneath the east third of the canyon bottom, where the bedrock channel is deepest. At this level the east portion of the rock floor of the canyon appears to be less substantial than the west, whereas higher in the canyon sides, the west wall is more broken than the east.

Because of the existence of the same conditions beyond the site, together with the less favorable topography both up and downstream, it is not possible to find materially better conditions at any other location in the immediate vicinity of the forks.

The character of the rock in the west wall of the canyon, where the proposed dam would rest upon and against it, is displayed in the abutment excavation. It is here shown to be broken through by an intricate system of fault planes with dips ranging from essentially vertical through intermediate angles to flat-lying and with strikes to nearly all points of the compass. Some of the fault lines may be traced across the excavation in a north-south direction and they thus parallel the canyon, while others appear to be correspondingly extensive in transverse directions.

Fault Planes.—Intersection of the fault planes and joints with which the rock is traversed has separated or split

the mass of the abutment rock into blocks of all sizes. Evidence of movement between contiguous blocks is the presence of a film or band of clay gouge, which when wet is smooth and slippery clay, and when dry, crumbly and gritty. There is often also a variable thickness of fault-breccia or shattered rock.

The fault planes are lines or surfaces of relatively ready percolation of water, by which alteration and softening of the adjacent rock has resulted. The inner parts of the larger blocks are usually comparatively hard and fresh rock; those of the smaller ones crumbly or in varying state of disintegration.

In excavation, separation takes place most readily along the slip surfaces between blocks. Where these are steep and approach parallelism with the canyon side, conditions are favorable to slumping of masses, such as the body of broken rock included in the recent "side" at the northerly side of the west abutment excavation.

No Suitable Foundation Rock Found.—The test shafts, tunnels and borings so far made give little hope that the conditions described above will materially improve with continued excavation. These explorations indicate that no suitable foundation rock for a high masonry dam is available under portions of the west abutment to distances of at least 190 ft. horizontally and 150 ft. vertically beyond the present excavation lines.

At the present time the face of the east abutment excavation has the appearance of being less broken and more substantial than the west side. In excavating into this wall the rock has separated, leaving a face determined by a set of well-defined smoothed surfaces, nearly parallel to the natural slope at this side.

This coincidence of position of a plane of separation with the average slope of the canyon side is to an extent deceptive, for it gives less favorable opportunity to see the actual physical condition of the abutment rock than at the west side. In the top portions of the excavation, however, the same intricate combination of faulting and crushing appears as in the west side. There is reason, therefore, to anticipate that greater depth of excavation may show a similar degree of instability at other levels in this abutment.

While the present excavations and exploration tunnels in the east abutment give promise of more satisfactory foundations than are available in the west abutment, neither the tunnels nor the borings on this side extend far enough to settle this point definitely. Furthermore, even the best rears of rock in this abutment are sufficiently intersected by planes of weakness and joints, some of which contain soft material, to throw doubt on its suitability for a dam of the height proposed.

The bedrock in the floor of the canyon, as shown by the drill cores and by the shafts now being put down, is of the same types of rocks as the canyon walls. In portions of many of the drill holes only a small percentage of core, or even no core, was recovered on account of the poor condition of the rock and both fault breccia and clay gouge are found in some of the cores.

The inference to be drawn from all available data is that the foundation rock in the canyon bottom is broken and is traversed by fault lines to an extent comparable to what is seen in the canyon side walls and abutment excavations. There is good reason to believe that strongly developed lines of break run lengthwise as well as across the canyon floor. Weathering and oxidization are not so general at this lower level, although these effects in certain places reach as deep as explorations have gone.

The fundamental requirement for a high concrete gravity dam is that it be built on firm, sound rock, of uniform compressibility. This condition does not exist at the San Gabriel site.

The Unanimous Opinion of the Board.—It is the unanimous opinion of this board that the foundation conditions are such that the dam proposed in application No. D-175 cannot be constructed without creating a menace to life and property.

While the primary purpose of this report as covered in the preceding pages is to advise on the safety of San Gabriel Dam, as proposed in the plans submitted by the Los Angeles County Flood Control District, the board in its investigations has come to the conclusion that the foundations and other conditions are suitable for a properly built flexible-type dam of conservative proportions. Such a type would not only conform to foundation conditions, but would also provide a structure which can best withstand earthquake shock or earth movement.

Flexible Type Dam Could be Built.—The board is of the opinion that a combination earth and rock fill dam, placed by the hydraulic method with concrete core wall, can be constructed safely at the site under consideration. The location of the reservoir site above a thickly settled and highly improved valley necessitates unusual precautions in the design of the dam, such as limited height, adequate cutoff, large freeboard, flat slopes and an ample downstream toe blanket. It calls for a spillway of generous capacity, designed for maximum floor occurrence. Unless conditions as now disclosed are found to be materially different upon further exploration, the board believes a safe dam of this type can be constructed at this site. Such a dam should be of width up and downstream to provide a percolation distance (length of water travel) along the base of the dam, equal to at least eight times the maximum depth of water against the dam. In addition to these conservative proportions, the dam should be provided with a reinforced concrete core wall, extending a proper distance into the bedrock at all points, in order to increase percolation resistance. Sluiced mat should also extend to bedrock in an open cut on the two sides of the core wall, the mat immediately up-stream from the concrete wall constituting the impervious core, the mat immediately below the core wall to consist of sand only. Such construction would prevent the travel of water in dangerous amounts either around or under the dam, and would provide a safe structure even though the concrete core wall were breached. The surface of the abutments above the crest of the dam should be brought to slopes that will prevent slides. Materials excavated to date from the abutments can be utilized in the earth-and-rock-fill type of dam suggested above.

Inspection of Valves and Fire Hydrants

At the Third Annual Conference of the Maryland Water and Sewerage Association Carl A. Heckmer of the Washington Suburban Sanitary District, Hyattsville, Md., gave the following suggestions as to what constituted a proper inspection of valves and fire hydrants:

Valves.—Semi-annual inspection advisable through Fire Underwriters' requirement is yearly inspection.

Covered valve boxes should be brought to grade.

All boxes cleaned of debris.

Set valve key on nut—pour kerosene or diluted crank case drawings down valve key—oil will run down the valve stem, lubricate it and revive packing.

Operate valve up and down, thereby cleaning groove of sediment and rust which is pushed out sides of groove.

Count number of turns—same for same make and size. This will bring to light bent valve stems or debris under gate without actually closing down main.

Grease gears on large valves—clean teeth of gears with wire brush.

Fire Hydrants.—Physical examination of hydrant first, condition of operating nut, nozzle threads, general appearance.

Turn on water with all caps on—listen with aquaphone for leaks in drain valve or hydrant barrel—note if all nozzle caps are tight in hydrant—measure static pressure by placing one cap on hydrant with pressure gauge attached.

Turn off water—remove nozzle cap and note rate of drainage.

Flush out hydrant noting residual pressure on one nozzle and rate of flow with pitot tube gauge.

Production and Collection of Sewage Gas

Its Advantages in Eliminating Nuisance Around the Disposal Plant and Performing Useful Work, with an Account of the Installation at Springfield, Mo.

By GEORGE S. RUSSELL

Russell & Axon, Consulting Engineers, St. Louis and Springfield, Mo.

THE gases given off from the sludge digestion chamber of either an Imhoff tank or a separate system of sludge digestion are various. The principal constituent, however, is methane, or marsh gas, which can be burned, and as a heat producer has a value between that of the artificial and natural gases used for domestic cousumption. This gas in itself has very little odor, but the other gases with which it is combined, such as sulphurated hydrogen, give rise to most of the obnoxious odors found around a disposal plant.

It can readily be seen then, that if some method of collecting and burning this gas can be devised, we are performing two services. First, we are eliminating one of the worst nuisances around the disposal plant, and second, we may use this waste product to perform useful work.

Some of the large plants in Germany are now collecting the waste gases given off from Imhoff tanks and utilizing them in various ways, either at the plant itself or by piping it into the local gas mains.

The Antigo, Wis., Installation.—One plant in the United States which has made use of this idea, and has been of interest to engineers generally, is the plant at Antigo, Wis. In this plant, which is of the separate sludge digestion type, the gas from the digester is collected and burned in a hot water heater. The hot water from this heater is carried through coils in the digester and serves to increase the temperature of the sludge. On account of the severe winters at Antigo, bacterial reduction is practically nil throughout a large portion of the year and some method of heating the sludge is necessary for satisfactory sludge digestion. Due to the results obtained at Antigo, the writer decided that what was practically a necessity at Antigo might still be made an economy in Missouri.

The optimum temperature for bacterial action, especially as pertaining to sewage reduction, according to various investigators, lies somewhere between 70° and 80° F., while at 40° F. the bacteria are practically inert. As the temperature of ordinary sanitary sewage varies in this latitude from about 40° or 45° in the winter to about 65° or 70° in the summer it is readily seen that this bacterial action is never at maximum efficiency and during the winter months we are getting very little if any reduction. This requires additional capacity for storage of sludge during the time that the bacteria are dormant.

It can be readily seen, then, that less sludge capacity will be required where some provision is made for heating the digestion chamber than under ordinary conditions and if this saving in capacity and consequent saving in construction cost is sufficient to justify the installation and operation of heating equipment, then the latter type will be the more economical. The amount of saving will depend on the range of temperature in the locality where the plant is being installed.

The Plant at Springfield, Mo.—The new plant at Springfield, Mo., is one of the separate sludge digestion type and has a contributory population of about 45,000 people. The writer made alternate designs for the digestion tanks in this plant. The one allowing for no heating had a designed capacity of 2 cu. ft. per capita and required two 50-ft. tanks averaging 21 ft. deep. The alternate design was for a single tank, 65 ft. in diameter and averaging 20 ft. deep, equipped with gas domes and heating coils. This tank has a capacity of 1½ cu. ft. per capita.

The price bid for the latter alternate fully equipped with coils, heater, pressure regulator, etc., was almost exactly the same as for the larger capacity and this alternate was built.

Results at Springfield Plant.—The writer had hoped to have a full report of definite data on this plant to present at this meeting, but due to the breaking of one of the pipes in the heating system, our records are incomplete at this time. We trust that we may give you more exact information in this connection later. However, the writer has sufficient information to feel justified in stating that even for the period from May 1 until the present time the increased efficiency will more than justify the 25 per cent reduction in capacity.

The present sewage flow in this plant ranges from 2½ m.g.d. to about 5 m.g.d. and the gas production from 22,500 to 27,000 cu. ft. We estimate that it will take from 10,000 to 15,000 cu. ft. for the digester. The city is installing hot water radiators in the plant for winter heating purposes, which last year took about two tons of coal per week and we still feel that there will be an excess of gas.

The use of heat in the digester has kept the sludge in excellent condition. In spite of the fact that for nearly a month, a new creamery emptied sufficient milk wastes into the sewer to make the sedimentation tanks look like they were filled with milk, the hydrogen ion content of the sludge has never shown an acid condition, falling as low as 7.0 but averaging between 7.2 and 7.3.

It is therefore self-evident even at the present time that this heating of the sludge gives better digestion and eliminates many of the troubles usually experienced in the operation of this portion of a disposal plant.

Results That May Be Expected.—It seems that the collection of gas from a sewage disposal plant and the utilizing of this gas for heating purposes may well be expected to accomplish the following results:

(1) Eliminate odors incident to Imhoff tanks or separate sludge digestion by the burning of waste gases.
(2) Decrease operating troubles due to maintenance of optimum conditions for sludge digestion.
(3) Decrease first cost by reducing the amount of sludge capacity required more than enough to offset cost of heating system. (This depends on range of temperatures at point of installation.)
(4) Decrease operation cost, due either to utilizing the waste gas for heating of buildings at the disposal plant or the sale of this gas for heating purposes.

Acknowledgment.—The above is a paper presented at the 5th annual Missouri Water and Sewerage Conference.

North Carolina Section Elects Officers.—The North Carolina section of the American Water Works Association at its convention last month at High Point, N. C., elected the following officers:

C. W. Smedberg, Superintendent of the water department of Greensboro, was elected president to succeed McKean Maffitt. T. C. Patterson of Mount Holly, was named vice president to succeed P. T. Dishner of High Point. Both H. G. Baity of Chapel Hill, and E. G. McConnell, of Charlotte, were re-elected secretary-treasurer and editor, respectively. The 1930 convention will be held at Hendersonville, N. C.

Weather As Affected By Electron Migrations

Why It May Be Possible to Forecast Weather Changes with Considerable Accuracy Far in Advance

By HALBERT P. GILLETTE

AT least in temperate latitudes there is an almost continuous flow of electricity from the earth, into the air. The source of this current has puzzled scientists. Perhaps the most commonly accepted theory is that of Bauer, who believes that the electrons come from the sun, and that they enter the earth in the polar regions, flow to lower latitudes and escape thence into the air.

It seems to me unnecessary to assume a solar origin of these electrons. All that need be assumed is that electrons circulate between two great magnetic fields in the earth, a lower field and an upper field, the latter being the well known Heaviside layer of electrons, 75 miles or more above the earth's surface. Electrons moving in orbits constitute an electromagnet, and since electrons in the air as well as in the earth rotate a full circle every 24 hours, with the earth, they constitute electromagnets. But, being free to move, these rotating electrons are repelled or attracted by other magnetic fields, such as the fields of sunspots and the fields of other rotating bodies like the sun, planets, etc.

Most of the sunspots rotate in opposite directions in the sun's two hemispheres, and therefore have opposite magnetic polarity. Hence when sunspots of a given polarity (N or S) predominate, their magnetic fields must tend to repel, the earth's rotating electrons having similar polarity. Due to the inclination of the earth's axis there must be an alternation of repulsion and attraction every six months, according as the earth's north or south pole points most directly toward the sun. This alone would cause important migrations of electrons in the earth and its atmosphere. There is also to be considered the inclination of the sun's axis, for the sun itself is a huge magnet. Finally, every one of the seven visible planets, not to mention several others not yet visible, must be counted upon to produce periodic migrations of the electrons in the earth and its air, depending upon the position of the magnetic axis of each planet relative to the earth.

So we have abundant means for producing a never ceasing flow of the earth's electrons, at times slow and at other times rapid. In short, electron currents must always exist in the earth and its atmosphere; and we need not assume that a single electron travels from the sun to the earth.

When sunspots are most numerous, obviously the migrations of electrons between the upper and lower magnetic fields of the earth will be very pronounced. This explains the fact that aurora are very frequent at or about the time of sunspot maxima. There is a great sunspot cycle of 11.2 years, and a similar cycle of auroral frequency exists. I have seen no mention of an intermediate auroral "peak," but I find that there is frequently one that is very pronounced, about half way between the 11.2-year "peaks." I find that these intermediate auroral "peaks" occur when Jupiter's north magnetic pole points most directly earthward, and that at such times there is usually a rainfall "peak" also. Douglass had previously noticed this intermediate rainfall peak, but had offered no explanation of it.

In this connection it may be well to point out that although the 11.2-year sunspot cycle is very regular, the corresponding rainfall cycle is less regular; for the earth is revolving around the sun at a mean distance of about 93,000,000 miles, and Jupiter is revolving at a distance five times as great and with an orbital velocity less than half that of the earth. In consequence of the changes in relative position of these two planets, there is a seeming lack of periodicity in the rainfall due to Jupiter's magnetic effect on the earth's electrons; but it is easy to calculate just when Jupiter's magnetic axis points most directly earthward; and I find that in every such case there has been a marked increase in rainfall in northern latitudes, provided that it was during the rainy season. This proviso merely means that Jupiter's magnetic field must be assisted by the fields of the earth and sun if much rainfall is to result.

The earth's axis is most inclined relative to the sun about June 21 and Dec. 21; and the sun's axis is most inclined relative to the earth about Mar. 8 and Sept. 8. Hence between Sept. 8 and Dec. 21, there occurs the maximum migration of electrons toward the north pole, and the converse between Mar. 8 and June 21.

In addition to the migration of electrons, there are two other important factors that affect the number of electrons in any region, namely, temperature and pressure. A rise of temperature releases electrons from atoms, and so does a fall of pressure. Hence in the summer and early autumn, electrons increase in number, which accounts largely for the thunder storms at that time. At high altitudes the electrons are more numerous than at low altitudes, which assists in explaining the increase in preciptation at high altitudes; for wherever electrons are numercus electron-whirls are most powerful, other things being equal, and electron-whirls impart a spirally ascending motion to the air.

Electron-whirls are caused by the action of the earth's magnetic field. This explains why cyclonic storms rotate in opposite directions in the earth's two hemispheres. I have little doubt that practically all air currents of meteorological impotance are created by electron-whirls. If so, weather is primarily an electrical phenomenon; and since electrical changes in the earth and its air are mainly the results of astronomical factors (sun, planets, etc.), it will become possible to forecast weather changes with considerable accuracy, far in advance. Eventually such forecasts will state approximately the inches of rainfall in each district during each rainy season. Indeed I shall not be surprsied if it becomes feasible to estimate the rainfall by months, with no slight degree of accuracy.

Ohio Filter Men Meet

The 9th annual Ohio Conference on Water Purification, was held Oct. 24 and 25, at the Fort Hayes hotel in Columbus. Of special interest were papers presented on the taste and odor problem and the sanitation of swimming pools. Visits were made to the Marble Cliff Quarries and to the new water softening plant at Marysville.

Officers for the ensuing year were elected as follows: O. F. Schoepfle, Sandusky, chairman; F. E. Sheehan, Portsmouth, vice chairman; J. M. Montgomery, Piqua, secretary-treasurer; Geo. M. Lieber, Fremont, and J. Sheldon Scott, Steubenville, members executive committee.

Fremont and Dayton invited the conference to hold its 1930 conference in those cities. Action with regard to the location for the next year's conference will be decided by the Executive Committee, which will be influenced by the choice of meeting place for the fourth Annual Sewage Treatment Conference. Its meeting place also is to be decided by its executive committee.

Water Works and Sewerage

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Announcing Three New Editors

We take pleasure in announcing that three new associate editors, each an outstanding authority in his field, have been added to the staff of *Water Works and Sewerage*. Mr. John R. Baylis will have a section on Walter Filtration Plants; Mr. John R. Downes will have a section on Sewage Disposal Works and L. H. Enslow will write on Sanitation, particularly the application of chlorination in the water works and sewerage field.

Mr. Baylis is Physical Chemist, Division of Operation, Bureau of Engineering, Department of Public Works of Chicago. He is in charge of the experimental work on the filtration of the Lake Michigan water for Chicago, and in this capacity designed the Chicago Experimental Filtration Plant, which is the largest and most elaborate plant of its kind ever constructed. Previous to coming to Chicago in 1926 he was principal sanitary chemist, Montebello Filters, City Water Department, Baltimore, Md.

Mr. John R. Downes is Supervising Engineer of the Plainfield and Dunellen, N. J., Joint Sewerage Disposal Works. Mr. Downes has been active in the sewage disposal field for many years. He was in charge of the sewage disposal works of Plainfield, N. J., from 1913 to 1916, in the latter year becoming supervising engineer of the joint sewage disposal works. He was the first president of the New Jersey Sewage Works Association and he was largely responsible for the establishment of the New Jersey Experimental Station.

Mr. Linn H. Enslow is Research Engineer of The Chlorine Institute, Inc. Mr. Enslow in collaboration with Abel Wolman developed the excess chlorine or "residual chlorine" method of controlling chlorine dosage, which is now in universal use in the sanitary field. He formerly was superintendent of the filtration plant of Spartanburg, S. C., and later of the filtration plant at Gatun, Canal Zone. He has been research engineer of The Chlorine Institute since 1925.

These new editors were selected because of their particular fitness for the work they are to handle. Thus the readers of Water Works and Sewerage will be kept informed of the very latest developments and the best practice in the water purification, sewage disposal and chlorination fields.

Hoover's Great Construction Program for 1930

There has been a reduction in the construction of dwellings and industrial buildings (but not in public works) during the past six months. On the heels of this came the stock market slump. President Hoover and his great secretary of the treasury, Andrew Mellon, have announced that they do not regard the deflation of stock prices as an evidence of business weakness. On the contrary they attribute the decline in building to the high rates of interest brought about by abnormal stock market speculation and the flow of money into Wall Street.

Now that the stock speculation bubble has burst, Hoover has announced that he favors a great expansion of public works; and as the first great step in this program he proposes extensive river improvements and canalization that will ultimately result in reduced costs of transporting grain, coal, etc. He also favors enlarged programs of municipal, county and state construction of pavements, roads, water works, sewerage systems, etc. Without doubt the president's great prestige as an executive, engineer and political economist will cause his recommendation to be adopted. So there is assurance that 1930 will be the greatest year of public works construction in the history of America.

In addition to the impetus thus assured under the Hoover plan, it should be remembered that gasoline taxes are financing most of our road improvement programs. In California the monthly gasoline tax incomes are running 16 per cent ahead of those of a year ago. Most of the other states are also showing remarkable increases in gasoline sales, which means corresponding increases in funds available for road construction. Nor should the effect of increased production of automobiles and motor trucks be overlooked, not merely because of its effect on gasoline consumption but because of the increase in the number of voters who will insist upon having better pavements and wider and better roads. It is now certain that the total number of American motor cars and motor trucks produced in 1929 will be about 5,500,000. The old cars are not being scrapped at the rate that once was common, for cars are more durable and we are rapidly becoming a two-car-per-family nation.

As a result of President Hoover's business and economic conferences the greatest construction program in the history of the country has been developed for 1930. It is estimated that this will amount to over $10,000,000,000 and will include the following:

Roads and Streets	$2,200,000,000
Waterworks and Sewers	700,000,000
Steam Railway Construction	400,000,000
Federal Government Construction	750,000,000
Public Utilities	1,000,000,000
Building Construction	5,500,000,000
Total	$10,550,000,000

Nation's Purchasing Power Not Affected by Stock Deflation

In not a few recent articles it has been said that, aside from some reduction in the buying power of the "fleeced lambs," no industrial injury has occurred as a result of the drastic deflation of stock prices. A little thought shows that not even this reduction in buying can affect the total buying power of the nation.

To begin with the earnings of the stocks remain unaltered by their reduced market prices, and it is only their earnings that furnish buying power. The dividends may go to other owners, but this is merely a transfer of buying power. The annual surpluses remain with the companies, so the buying power that those surpluses represent does not change hands.

As to "paper profits" resulting from a rise in stock prices, they are not buying power until the stocks are sold and the profits are actually made available; but when that occurs, and money is transferred, by as much as the seller gains in cash with which to buy goods the seller loses in cash. So, in the final analysis, the total buying power of a nation is unaltered by any change in the prices of stocks, so long as no international trading is involved. International trading in stocks is trivial in comparison with national trading, so this factor need not be considered.

The well known and oft-repeated truth is that the vast majority of Wall St. transactions that involve stocks are gambling transactions. It is pure sophistry to argue that many of the stock buyers and sellers are investors, for active stocks are turned over so frequently that the nature of the transaction is clearly apparent. Most of us have a gambling instinct, so when public gambling on horse races and the like is barred by law, many of us turn to a sort of gambling that is not thus prohibited, and we call it speculating. We are far from implying that laws should be drawn to prohibit or even to curtail buying on margin. On the contrary, let freedom be unconfined, except, perhaps, that phase of it that enables pools to rig the market. Sooner or later men will learn that intrinsic values are not in the habit either of skyrocketing upward or of falling like the stick; and it is better that they learn to beware of such stock markets as we have witnessed in recent years than that they be forbidden to speculate.

In this connection it may be well to point out why many stocks had such a spectacular rise for several years following the close of the world war. Take, for example, public utility stocks. The editor, as a consulting engineer on public utility appraisals and rate cases, was employed by many public utility companies for several years following the war; and testified before commissions and courts as to the rise in wages, materials, taxes that made higher rates of charge necessary. Also it was shown that the values of utility plants had risen as a result of the rise in wages and in prices of machinery and materials; and fair percentages of profit on these higher values were likewise necessary under our constitution. As a result of such hearings, of which the ones in which the editor was engaged, were merely typical of hundreds, the rates of street car fares rose from 5 cents to an average of about 7 cents, and other similar, although usually smaller, increases were secured by utility companies in other fields. Prior to these increases in rates, utility common stocks had declined in price because of inadequate earnings. As increased rates went into effect, such stocks began to rise, and in many instances they increased several fold in price. Seeing such increases in stock values, accompanied by earnings that fully justified the increases, the public eventually came to think that there was no end to the gifts of the Santa Claus they called our American prosperity. So they began discounting anticipated increases in earnings of utilities and railways that were destined not to occur.

In the industrial field a general rise in earnings was also largely due to rise in prices of products, resulting from the inflation in currency that the war had caused. Here the effect was more spectacular than in the utility and railway fields, because it was more sudden. It was sudden because commissions and courts did not delay the rise in rates of charge. Competition usually could not check the rise, for a competitor had to buy lands and plant at prices that had advanced, and was thus forced to charge higher prices for his products, except in those rare instances where a complete offset to such increased costs could be secured through increased efficiency of machinery. Let the value of an industrial plant and lands double as a result of currency inflation, let that plant be mortgaged for half its original value, and let common stock at par equal the value of the other half. Then what happens is this: A plant capitalized at $1,000,000 (half bonds and half common stock) becomes worth $2,000,000, on which the bond holders have a lien of $500,000, leaving an equity of $1,500,000 that belongs to the holders of $500,000 par value of common stock, which now becomes worth $1,500,000, or triple par. As such a stock works up to such a triple value, speculators become inflamed by the sight of rising values. Many who buy secure enormous profits during the rise, and become imbued with the idea that they are Napoleons of finance. Not understanding the underlying cause of the rise, they attribute it entirely to American prosperity. They read that never before has our nation increased per capita productivity so rapidly (which is true, but not the cause of rising prices). They see no reason why this productivity should not continue to mount, so they infer that stock prices will continue to mount, and err because their premise is wrong. Increasing per capita productivity does not increase prices; it decreases them. The industrial companies who are able to show rising net earnings per dollar of invested capital are only those that excel the others in efficiency. These, however, are in the minority, but they are a spectacular minority; and the continued rise of the value of those stocks adds fuel to the speculative furnace—until, at last, the boiler explodes.

Almost any stock purchased seven or eight years ago, following the post-war panic, was a bargain. Such purchasers came to believe that they had shown wonderful business acumen, when, if the truth were known, very few of them had correctly analyzed the problem, if we may judge from the writings of financial advisers during the last eight years. Babson, just before the recent crash, issued a warning to sell, but it is apt to be forgotten that he issued a similar one in 1921 at the very time that he should have been advising the purchase of stocks. And up to the very moment of the recent debacle, the great majority of the professional prophets in the realm of speculation were as optimistic as such prophets usually are.

During the editor's investigation of public utility rates, he analyzed the rates of return on the market values of all classes of American securities for many years back. Some of the conclusions thus derived were published in "Engineering and Contracting" and "The Analyst." The relation between the risk factor and the earnings of bonds and stocks was deduced; and the average "market price of money" was derived. Just before the recent bursting of the stock bubble of 1929, many stocks were selling at more than double the price warranted by the risk factor and the earnings. It was evident from such facts that "frenzied finance" was due for a fall. Many a banker had come to that conclusion. Our Federal Reserve System had issued repeated warnings. But it is the characteristic of nearly every one of us to be oblivious to such warnings, especially when we have ignored them and profited by ignoring them for a year or more. More than two years ago the warnings began to come from conservative bankers, but investors listened to market tipsters instead, and the headache of the day after is now theirs. We are deeply sorry for them. We have ourselves experienced, many years ago, their every feeling. Out of that bitter experience came the resolution never to buy stocks on tips, but to study methods of correctly appraising the intrinsic values of securities. You will be told that no values are intrinsic. This is quibbling over a definition. Certainly there are stock prices that exceed the present worth of prospective earnings, just as there are others that are below that worth. The successful investor, as distinguished from the speculator, first learns to appraise intrinsic values, and then backs his own judgment and not that of some tipster who sells or gives him advice but risks no money of his own.

Why Rock-Fill Dams Are Best Over "Dead Faults"

In several recent reports on dam sites in California, geologists and engineers have used the expression "dead faults," and "crustal stresses long ago adjusted." It is our opinion that there is no such thing as a "dead fault," if by that is meant a crustal crack along which no further movement will ever occur. To begin with it is little more than a guess to say that no recent movement along a fault has occurred, if by recent is meant within a century. And as for saying that no future movement will occur, obviously that is the wildest of conjectures. There are many instances of volcanoes that had been "dead" for generations, yet suddenly became alive. What, then, is the criterion of "death"? Only long inactivity, but "long" is an indefinite and purely relative term. At best the only sound inference that can be drawn from long inactivity is that the volcano is dormant. When it will awake, no one knows, but that it will awake some time is probable. The same is true of crustal movements along faults.

The editor has published evidence that indicates clearly the cyclic nature of volcanic and earthquake phenomena, as well as those great crustal movements that have elevated or depressed large continental areas. More evidence of the same sort will soon be published. Since application of the mathematical rules of probabilities to these data very strongly support the cyclic theory of crustal movements, both great and small, it is no longer logical to speak of any fault as being dead.

This being granted, it follows that no rigid dam should be built over a fault in any region where crustal movements are prevalent. The St. Francis dam is a case in point. It straddled a "dead fault" that suddenly came to life. See "Engineering and Contracting" (April, 1928) for the measurements that showed that a crustal movement took place after the dam was finished, and probably compassed its destruction.

The San Gabriel (Calif.) dam site is under investigation by several geologists and engineers. Already there is disagreement among the doctors, some alleging that the fault at that place is "dead," others, that it shows signs of recent slippage. It is not very material whether recent slippage has occurred or not. That slippage will occur some day is probable, for the region is one of repeated, although slight, crustal movements; none of which would injure ordinary structures, but any of which might destroy a rigid dam.

In a previous editorial article we advocated the use of a "rock-filled dam" for this site. After the writing of that article, but before its publication, E. C. Eaton, Los Angeles County flood control engineer, reported to the Board of Supervisors that it might be wise to substitute a rock-fill design for the concrete, at least on the west abutment. He recommended a careful study of the 250-ft. rock-fill dam at Bowman, near Fresno, Calif. He suggested that the eastern part of the dam be made of concrete as originally designed. It is our opinion that it would be wiser, and probably cheaper, to make the entire dam a rock-fill structure about 250 ft. high. It would then be flexible throughout, and unquestionably safe.

No rock fault should be regarded as being unquestionably dead. Hence dams over faults should be either earth or rock-fill or a combination of both, well sheeted on the upstream face.

Since the foregoing was written, New England has experienced the most severe earthquake shock in 174 years. Incidentally, crustal movement along the Dundian fault, near the Bay of Funday, is believed to have severed nearly half of the score of cables that cross the Atlantic Ocean from that region. The first Atlantic cable was laid in 1858, more than 70 years ago, and this is, we believe, the first instance of cable breakage due to a crustal movement. Had geologists been previously consulted as to the risk of such an accident near the Dundian fault, it is likely that there would have been a difference of opinion, with the majority inclined to call it a "dead fault." In some respects geology is almost an exact science. In most respects it is still embryonic and very inexact. Of this the editor is convinced both by his college training, as a mining engineer and by his recent studies of crustal movements and the geological literature on the subject.

H. P. Gillette

BIG AND LITTLE, RICH AND POOR, CAN PROJECT THEIR PERSONALITIES OVER THE WIDE NETWORK OF ITS WIRES

In the service of all the people

An Advertisement of the
American Telephone and Telegraph Company

THE Bell System is owned by 450,000 stockholders and operated by more than 400,000 workers for the service of the people of the nation.

It is a democratic instrument of a democracy. Big and little, rich and poor, can project their personalities over the wide network of its wires. For friendship or business, pleasure or profit, the telephone is indispensable to our modern civilization.

This year the Bell System is erecting new telephone buildings in more than 200 cities. It is putting in thousands of miles of cable, thousands of sections of switchboard and hundreds of thousands of new telephones. Its expenditure for plant and improvements in service in 1929 will be more than 550 millions of dollars—half again as much as it cost to build the Panama Canal.

This program is part of the telephone ideal that anyone, anywhere, shall be able to talk quickly and at reasonable cost with anyone, anywhere else. There is no standing still in the Bell System.

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Harlow H. Curtice

Thirty-six year-old executive recently appointed president and general manager of A. C. Spark Plug Company to succeed Basil W. deGuichard

Water Tapping Invention Starts Mighty Industry

Necessity that same old mother that has brought into the world so many inventions started Hieronymus Mueller, founder of Mueller Company, Decatur, on a course of events which has resulted in an establishment with an annual payroll of approximately $2,000,000.

This aforementioned Hieronymus Mueller came to this country from Germany in 1849 and after trying out Chicago and Freeport decided that Decatur was to be his future home. This was in 1857. Mr. Mueller was a mechanic and for many years conducted a gun and locksmith shop. But being a mechanic he understood the needs of water works and when Decatur built a water works plant he became the city plumber.

In 1881, when Mr. Mueller was 49 years old, he was called on in his capacity of plumber to tap a water main. Before the work was successfully completed Mr. Mueller had to drive to the pumping station to have water shut off, and after the connection was made had to drive back to have the water turned on. Enough to make a good plumber think, way back in the days when there were no telephones and no automobiles to speed things up.

So it was that Mr. Mueller decided to invent a machine to tap a water main without having to shut off the water. The machine worked and he patented it and proceeded to manufacture it for the benefit of water works men all over the country. To make the cocks required for this machine as they should be, resulted in starting a small brass foundry, and now this branch of the Mueller Company manufacture tapping and drilling machines, water works brass and iron goods and plumbing brass goods.

The vitreous ware plant now forms one of the most important branches of the Mueller works. Here clay brought from Kentucky, Tennessee, New Jersey and even Europe is operated on and turned out in finished sanitary bathroom furniture. The plant has a capacity of turning out 500 pieces a day and keeps a hundred skilled workmen busy.

Altogether 1,500 workmen share in the $2,000,000 annual payroll of the Mueller Company, which is now operated by six sons of the founder, the president and general manager being Mr. Adolph Mueller. Mr. Hieronymus Mueller, inventor of the tapping machine which is now used by practically 90 per cent of the water works throughout the country died in 1900.

Headley Emulsified Products Succeeds Headley Good Roads

The Headley Emulsified Products Company, on October first, became the successor to Headley Good Roads Company of Philadelphia, who for 21 years have manufactured emulsified asphalt products. The new company it is stated will expand this line to cover all of the following industrial uses: Highway construction and maintenance, railroad platforms and crossings, waterproofing, dampproofing and protective coatings for all types of structures.

The officers of the new corporation are: President, Edgar S. Ross, Director of Research and Development of the old company, and formerly in charge of investigations on roofings and waterproofings at the Mellon Institute of Industrial Research; Vice-President, Parmely W. Herrick, of the Herrick Company, Cleveland, Ohio; Vice-President and Treasurer, M. W. Lefever, for 15 years in a similar position with the Headley Good Roads Company; Secretary, Geo. D. Webster, Esq., of Cleveland.

According to announcement the present plant at Marcus Hook, Pa., will be supplemented by other manufacturing facilities to be located at points not yet determined.

"Caterpillar" Appoints Chambers Western Manager

H. H. Chambers has been appointed sales manager of the western division with headquarters at San Leandro, California, for the Caterpillar Tractor Company.

Mr. Chambers succeeds I. E. Jones, who according to announcement issued by the company, is embarking on an extended trip through foreign lands in the interests of the export sales division. E. I. Stoffer, former district representative in Pennsylvania and New York for Caterpillar, will take Chambers' place in the eastern division.

The appointment of Mr. Chambers to his new position is announced as a promotion, his connection with the company having started fourteen years ago as a laborer on the assembly line, where he spent three years. He served in the army during the World War and rejoined the Caterpillar company as a member of the sales promotion and advertising department. Later he spent three years as salesman and general manager for a Wisconsin Caterpillar dealer.

H. H. Chambers, Newly Appointed Western Sales Manager for Caterpillar Tractor Co.

Can you think of anything that will last longer than a vitrified clay sewer?

CLAY PRODUCTS ASSOCIATION
CONWAY BUILDING
Chicago

VITRIFIED Salt Glazed CLAY
Sanitary Sewer Pipe

WW 12-Gray

A Quick Set-up
for a short job

Every day small jobs on the street require temporary protecting barricades like this.

This one was made with a single board and a pair of TOLEDO HORSE frames. When the job was done, it was knocked down in just a few seconds, and tossed under the seat of a small truck all ready to set up as quickly on the next job.

THE TOLEDO HORSE
meets all requirements of

utility, — *Aside from barricades, there are hundreds of ways every user will find them convenient.*

safety, — *They are absolutely rigid, and if necessary one pair will support twelve ton.*

convenience and economy — *They use any piece of handy lumber, are fully collapsible, and can be carried or stored in very small space.*

They are indestructible and will last indefinitely, without repairs.

See them at your dealer's, or write us for full details.

THE
Toledo Pressed Steel Co.
TOLEDO :: OHIO

Maurer, Prominent in Wisconsin Highway Affairs, Joins Heil Company

The Heil Co. announces the recent appointment of Mr. C. N. Maurer, a prominent figure with the Wisconsin State Highway Commission for the past ten years, as Director of the Highway Sales Division of the Heil Co.

Mr. Maurer has recently been highly acclaimed for one of his outstanding achievements as traffic engineer of the Highway Commission namely, formulating the new Wisconsin Traffic Code which became effective November 4th, 1929.

Mr. Maurer's first big assignment with the Highway Commission was the securing, reconditioning and distributing of surplus war equipment to the counties. Over a period of six years he supervised the allocation of several millions of dollars worth of surplus war equipment.

C. N. Maurer

When this job was completed Mr. Maurer was appointed Traffic Engineer of the Highway Commission. In this capacity he supervised the remarking of all Wisconsin Highways, installed the department to handle the weight law enforcement of vehicles and developed the State Highway Arterial System.

These activities over a period of years formed a splendid background for preparation of the State Traffic Code.

Mr. Maurer is a graduate mechanical engineer of the University of Wisconsin. He was a First Lieutenant during the war with a 19 months overseas service record. He is a member of the Society of Automotive Engineers and Wisconsin Engineering Society; Chairman of the Board of Directors of the Madison, Wisconsin, American Automobile Association, and also the Wisconsin Member to the A. A. A. National Good Roads Committee.

Mr. Maurer joins the Heil Co. with a broad understanding of Highway development work. His experience admirably fits him for his new work in representing Heil Hydraulic Hoists and Heil All-Steel Dump Bodies for motor trucks.

Hardinge Company Announcement

Mr. Howard G. Wright, formerly chief engineer of the North American Cement Company, Catskill, New York, has joined the staff of the Hardinge Company as research engineer in the cement machinery department. Mr. Wright will devote a large part of his time to working up engineering data for the various classes of Hardinge equipment used in cement plants, according to announcement.

Mr. John L. Mason, formerly sanitary engineer for the Water Works Supply Company, San Francisco, California, has become sewage research engineer for the Hardinge Company. Mr. Mason collaborated in the development of the "Watsco" Aerator for the activated sludge treatment of sewage, and has had extensive experience in the far west in the design and manufacture of mechanical equipment installed in sanitation plants.

Lockwood Hill Forms Equipment Company

Announcement has been made to the effect that Lockwood Hill, for the past ten years a member of the Blackman Hill Company of St. Louis, Mo., has organized a new company to be known as the Hill Equipment Engineering Company with offices at 4620 Delmar Boulevard, St. Louis.

Announcement states that the new organization is to have the exclusive sale of the products of the Lincoln Electric Company, and the Baker Industrial Truck Company in the St. Louis Metropolitan District, and the Eastern Missouri and Southern Illinois territories. The company will carry a complete stock of "Linc-Weld" motors and "Stable-Arc" welders, welding supplies, accessories and parts.

Prior to his association with the Blackman Hill Company, Mr. Hill was assistant to price approval officer in the St. Louis district ordinance office of the U. S. Army. He also served in the testing and foreign departments of the General Electric Company, and in the power and mining department in the St. Louis district office of this company.

It is said that early in Mr. Hill's business career he sold the first arc welders in the St. Louis territory. He is a graduate of the class of 1909, Cornell University, where he received his degree in mechanical engineering and a certificate in electrical engineering.

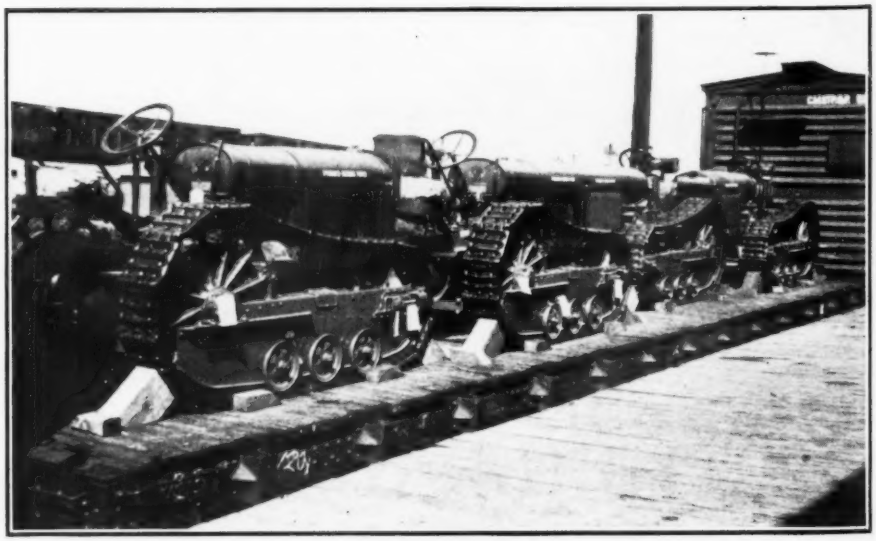
Announcement

The Independent Pneumatic Tool Company, 600 W. Jackson Boulevard, Chicago, announces the following organization changes:

Mr. Joseph P. Fletcher, manager of the company's Buffalo office, has been appointed manager of the Philadelphia office to succeed the late Mr. A. L. Schuhl.

Mr. W. O. Becker, who has been working out of the Toronto office, has been named as manager of the Buffalo office to succeed Mr. Fletcher.

E. F. Doty Pump Co., Inc., manufacturers of corrosion resisting pumps of various alloys, announce that they are now manufacturing rubber lined and covered centrifugal pumps. The surfaces in contact with corrosive fluids are covered with rubber by B. F. Goodrich Rubber Co's. "Vulcalock" process. These pumps have been developed in sizes up to 6 in. discharge. Headquarters of the Doty Pump Company are located at 401 Ellicott Sq., Buffalo, New York City.



Fleet of 24 Model LH Trackson McCormick Deerings on Way to Texas

WATER WORKS AND SEWERAGE DATA SECTION

1929

A Data Section of Engineering Information Relating to the Design, Construction, Operation and Maintenance of Water Works and Sewerage, Compiled by Halbert P. Gillette, Editor of Municipal News and Water Works, Author of Handbook of Cost Data and Handbook of Construction Costs.

Also Geographical Index of Dealers and Distributors

Gillette Publishing Company
Technical Publishers
221 East 20th Street, Chicago, Illinois

FOREWORD

GILLETTE PUBLISHING COMPANY presents herewith the first edition of the Water Works and Sewerage Data Section of Municipal News and Water Works.

The Data Section has been prepared by Mr. Halbert P. Gillette and gives the equivalent of a 300 page handbook of data on the design, construction, operation and maintenance of water works and sewerage.

The Data Section together with the Geographical Index of dealers and distributors together with the manufacturers' data makes the edition a very complete and practical reference issue.

The demand for copies of this issue has been so great that the edition will be distributed to 16,000.

The Data Section is carefully selected matter from the files of Municipal News and Water Works and from other sources named in the text. In addition, scores of letters have been written to secure the latest hydraulic tables and standards and the most economical methods. In a word, the same conscientious work has been put into the writing of the Data Section as would be expected in a book devoted exclusively to this purpose.

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Aftercoolers, Air
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Ingersoll-Rand Co., New York City.
Sullivan Machy. Co., 819 Wrigley Bldg., Chicago, Ill.

Air Ducts, Steel
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Littleford Bros., 454 E. Pearl St., Cinnati, O.

Air Lifts
Chicago Pneumatic Tool Co., New York, N. Y.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Asbestos Lead Lined Runners
Coleman, Allan J., Chicago, Ill.

Asbestos Specialties
Philip Carey Co., Cincinnati, O.

Ash Handling Machinery
Haiss Mfg. Co., Geo., New York City.

Asphalt
Asphalt Association, New York City.
Barrett Co., New York City.
Kentucky Rock Asphalt Co., Louisville, Ky.
Servicised Products Corp., Chicago, Ill
Standard Oil Co. of Indiana, Chicago
Standard Oil Co. of N. Y., New York City.
The Texas Co., New York City.
West Process Pavement Co., Louisville, Ky.

Asphalt Pavement Repair Outfits
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
The Rightway Corporation, 228 N. La Salle St., Chicago, Ill.

Asphalt Plants, Portable
E. D. Entyre & Co., Inc., 63 Jefferson St., Oregon, Ill.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
The Rightway Corporation, 228 N. La Salle St., Chicago, Ill.

Augers, Pipe
Coleman, Allen, Chicago, Ill.

Axles
Electric Wheel Co., Quincy, Ill.

Back-Fillers
American Cement Machine Co., 251 E. Fourth St., Keokuk, Ia.
The Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.
Buckeye Traction Ditcher Co., Findlay, Ohio.
Bucyrus-Erie Co., Erie, Pa.
Byers Machine Co., Ravenna, O.
Chicago Pneumatic Tool Co., New York.
Galion Iron Works, Galion, O.
General Excavator Co., Marion, O.
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Industrial Brownhoist Co., Cleveland.
Keystone Driller Co., Beaver Falls, Pa.
Ohio Power Shovel Co., Lima, O.
Speeder Machinery Co., Cedar Rapids, Ia.

Back Stopers
Adams Co., J. D., Indianapolis, Ind.

Bags, Paper Cement
Bates Valve Bag Corp., Chicago.

Bar Benders & Cutters
Koehring Company, Milwaukee, Wis.
Ransome Concrete Machinery Co., Dunnellen, N. J.

Bar Chairs, Reinforcing
Concrete Steel Co., New York City.

Bars, Iron & Steel
Concrete Steel Co., New York City.
Ryerson & Son, Joseph T., Chicago.

Bars, Iron & Steel Reinforcing
American Steel & Wire Co., Chicago.
Truscon Steel Co., Youngstown, O.

Batch Boxes
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Western Wheeled Scraper Co., Aurora, Ill.

Batchers, Adjustable
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Butler Bin Co., Waukesha, Wis.
Erie Steel Construction Co., Erie, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Johnson Company, C. S., Champaign, Ill.

Batcher Plants
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Erie Steel Construction Co., Erie, Pa.

Beams
Carnegie Steel Co., Pittsburgh, Pa.
Ryerson & Son, Joseph T., Chicago.

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Hyatt Roller Bearing Co., Harrison, N. J.
S. K. F. Industries, New York, N. Y.
Timken Roller Bearing Co., Canton, O.

Binders, Paving
American Tar Products Corp., Pittsburgh, Pa.
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Philip Carey Co., Cincinnati, O.
Kentucky Rock Asphalt Co., Louisville.
Servicised Products Corp., Chicago.
Standard Oil Co. of Indiana, Chicago.
Standard Oil Co. of New York, New York City.
The Texas Co., New York City.

Bins, Storage
Butler Bin Co., Waukesha, Wis.
Johnson Company, C. S., Champaign, Ill.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.

Blades, Grader
J. D. Adams Co., Indianapolis, Ind.

Blocks, Tackle
Western Block Co., Lockport, N. Y.
Williamsport Wire Rope Co., Williamsport, Pa.

Bodies, Meter Box
Clark Co., H. W., Mattoon, Ill.

Bodies, Truck
Anthony Co., Streator, Ill.
Galion All Steel Body Co., Galion, O.
Lee Trailer & Body Co., Plymouth, Ind.
Wood Hydraulic Hoist & Body, Detroit.

Boilers, Steam
Orr & Sembower, Reading, Pa.

Boilers, Steel
Central Foundry Co., New York City.
R. D. Cole Mfg. Co., Newnan, Ga.
Industrial Brownhoist Co., Cleveland.

Bolts, Nails, Nuts, Rivets & Spikes
Ryerson & Son, Joseph T., Chicago.

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Gillette Publishing Co., Chicago, Ill

Bowls, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.

Boxes, Annealing
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Boxes, Meter
Clark Co., H. W., Mattoon, Ill.
Reading Meter Repair Co., Reading, Pa.

Braces, Trench
Kalamazoo Fdry. & Mach. Co., Kalamazoo, Mich.

Brands, Tool
Chicago Pneumatic Tool Co., New York City.
Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.
Ingersoll-Rand Co., New York City.

Breechings, Steel
R. D. Cole Mfg. Co., Newnan, Ga.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Brick
Hydraulic-Press Brick Co., St. Louis, Mo.
National Paving Brick Mfrs. Assn., Washington.

Brick, Enamel
Hydraulic-Press Brick Co., St. Louis, Mo.

Brick Loaders and Unloaders
Haiss Mfg. Co., Geo., New York City.

Brick, Mosaics
Hydraulic-Press Brick Co., St. Louis, Co.

Brick, Paving
National Paving Brick Mfrs. Assn., Chicago.

Brick, Salt Glaze
Hydraulic-Press Brick Co., St. Louis, Mo.

Brick, Vitrified
National Paving Brick Mfrs. Assn., Chicago.

Bridges
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Bridge Accessories
Armco Culvert & Flume Co., Middletown, O.
Inland Steel Co., 38 South Dearborn St., Chicago, Ill.
J. T. Ryerson & Sons, Chicago.
Wood Steel Co., Alan, Conshohocken, Pa.

Bridges, Suspension
John A. Roebling's Sons Co., Trenton, N. J.

Buckets, Back Filling
Garst Mfg. Co., Chicago.

Buckets, Clam Shell
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Erie Steel Construction Co., Erie, Pa.
Haiss Mfg. Co., Inc., Geo., New York.
Hayward Co., New York City.
Industrial Brownhoist Corp., Cleveland.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Orton Crane & Shovel Co., Chicago, Ill.
William Co., G. H., Erie, Pa.

Buckets, Concrete
Insley Mfg. Co., Indianapolis, Ind.
Ransome Concrete Mchry. Co., Dunnellen, N. J.

Buckets, Contractors
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Buckets, Dragline
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Harnischfeger Corp., Milwaukee, Wis.
Hayward Co., New York City.
Williams Company, G. H., Erie, Pa.

Buckets, Dredging and Excavating
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Garst Mfg. Co., Chicago.
Haiss Mfg. Co., Inc., Geo., New York.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, Ohio.
Osgood Company, Marion, O.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.
The T. L. Smith Co., 1031 32nd St., Milwaukee, Wis.
Williams Co., G. H., Erie, Pa.

Buckets, Excavating
Haiss Mfg. Co., Geo., New York City.
Harnischfeger Corp., Milwaukee, Wis.

Buckets, Orange Peel
Hayward Co., New York City.
G. H. Williams Co., Erie, Pa.

Buckets, Self Filling
Pioneer Gravel Equipment Co., Minneapolis, Minn.

Building Paper
Barrett Co., New York City

Buildings, Steel
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Bulldozers
The Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.
Trackson Co., Milwaukee, Wis.
Western Wheeled Scraper Co., Aurora, Ill.

Burners, Furnace
Aeroil Burner Co., Union Hill, N. J.
Hauck Mfg. Co., Brooklyn, N. Y.

Bushings, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.

Cableways
American Steel & Wire Co., Chicago.
Hayward Company, New York City.
Lidgerwood Mfg. Co., Elizabeth, N. J.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.
Wickwire Spencer Steel Co., New York City.

Cableway Excavators
(See Excavators, Cableway.)

Calcium Chloride
Columbia Products Co., Barberton, O.
Sales Agents Special Products, Columbia Chemical Division, Pittsburgh Plate Glass Co.
Dowflake Chemical Co., Midland, Mich.
Pittsburgh Plate Glass Co., Barberton, Ohio.
Semet-Solvay Co., 61 Broadway, New York, N. Y.
Solvay Sales Corp., New York City.

Calking Machines
Chicago Pneumatic Tool Co., 6 East 44th St., New York City.
Ingersoll-Rand Co., New York City.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Capstans, Windlasses and Winches
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Fdy. and Machine Co., Bay City, Mich.
Fulton Iron Works Co., St. Louis, Mo
Lidgerwood Mfg. Co., Elizabeth, N. J.

Car Pullers
Lidgerwood Mfg. Co., Elizabeth, N. J.

Car Steps, Safety
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Cars, Rwy.
Fairbanks Morse Co., Chicago, Ill.
Western Wheeled Scraper Co., Aurora, Ill.

Cars, Industrial V Dump
Insley Mfg. Co., Indianapolis, Ind.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Carts, Concrete
Insley Mfg. Co., Indianapolis, Ind.
Ransome Concrete Mchry. Co., Dunnellen, N. J.

Casings, Well
Armco & Culvert Mfrs. Assn., Middletown, O.

Castings, Builders
Clark Co., H. W., Mattoon, Ill.

Castings, Building
Fulton Iron Works Co., St. Louis, Mo.

Castings, Grey Iron
Fulton Iron Works Co., St. Louis, Mo.

Castings, Iron & Steel
American Casting Co., Birmingham.
Central Foundry Co., New York City.
Central Iron & Steel Co., Harrisburg, Pa.
Clark Co., H. W., Mattoon, Ill.
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Klauer Mfg. Co., Dubuque, Ia.
McWane Cast Iron Pipe Co., Birmingham, Ala.
Marion Steam Shovel Co., Marion, Ohio.
Pacific States Cast Iron Pipe Co., Provo, Utah.
W. A. Riddell Co., Bucyrus, O.
Geo. H. Smith Steel Casting Co., Milwaukee, Wis.
South Bend Fdy. Co., South Bend, Ind.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
Western Crucible Steel Casting Co., Minneapolis, Minn.
Wood, R. D. & Co., Philadelphia, Pa.

Castings, Municipal
Clark Co., H. W., Mattoon, Ill.
Fulton Iron Works Co., St. Louis, Mo.

Castings, Semi-Steel
Fulton Iron Works Co., St. Louis, Mo.

Castings, Street and Sewer
Central Foundry Co., New York City.
Clark Co., H. W., Mattoon, Ill.
James B. Clow & Sons, 201-299 N. Talman Ave., Chicago, Ill.
Klauer Mfg. Co., Dubuque, Ia.
South Bend Fdy. Co., South Bend, Ind.
U. S. C. I. Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Catch Basins, Corrugated Iron
Armco Culvert Mfrs. Assn., Middletown, O.

Catch Basin Covers
Central Iron & Steel Co., Harrisburg, Pa.
H. W. Clark & Co., Mattoon, Ill.
Galion Iron Works, Galion, O.
U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.

Cement
Philip Carey Co., Cincinnati, O.
International Cement Corp., New York, N. Y.
Marquette Cement Mfg. Co., Chicago, Ill.
Mo. Portland Cement Co., St. Louis, Mo.
Universal Portland Cement Co., 208 S. La Salle St., Chicago, Ill.

Cement Guns
Cement-Gun Co., Inc., Chicago, Ill.

Cement-Making Machinery
Allis-Chalmers Mfg. Co., Milwaukee.

Cementation Process
Dravo Contracting Co., Pittsburgh, Pa.

Centers, Steel, Collapsible
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Chain, Steel & Malleable
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Chemical Feeding Equipment
Bacharach & Co., E. W., Kansas City, Mo.

Chimneys
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
R. D. Cole Mfg. Co., Newnan, Ga.
Connery Company, Philadelphia.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Chloride of Lime
Dow Chemical Co., Midland, Mich.

Chlorine, Liquid
Hooker Electrochemical Co., New York.

Chlorinators
Paradon Mfg. Co., Arlington, N. J.
Wallace and Tiernan, Newark, N. J.

Chutes, Concrete
Insley Mfg. Co., Indianapolis, Ind.
Ransome Concrete Mchry. Co., Dunnellen, N. J.

Clarifiers
Dorr Co., New York City.

Clay, Fire
Clay Products Assn., Chicago.

Clay Spaders
Chicago Pneumatic Tool Co., 6 East 44th St., New York City.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Cleaners, Closet, Flexible Wire
Coleman, Allan, Chicago, Ill.

Closet Cleaner, Chemical Compound
Coleman, Allan, Chicago, Ill.

Clutches
Brown-Lipe Gear Co., Syracuse, N. Y.
Twin Disc Clutch Co., Racine, Wis.

CLASSIFIED INDEX OF PRODUCTS

Coal & Ore-Conveying Machy.
Byers Mch. Co., Ravenna, Ohio.
Haiss Mfg. Co., Inc., Geo., New York.
Lidgerwood Mfg. Co., Elizabeth, N. J.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Coal-Storage Systems
Lidgerwood Mfg. Co., Elizabeth, N. J.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.

Cofferdams, Steel
Bethlehem Steel Co., Bethlehem, Pa.

Column Forms
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Column, Wrapping
Ryerson & Son, Jos. T., Chicago.

Columns, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.
U. S. Cast Iron Pipe & Fdry. Co., Burlington, N. J.

Compressors, Air, Heavy Duty
Allis-Chalmers Mfg. Co., Milwaukee.
Chicago Pneumatic Tool Co., New York City.
Domestic Engine & Pump Co., Shippensburg, Pa.
Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.
Ingersoll-Rand Co., New York City.
O. K. Clutch & Mach. Co., Columbia, Pa.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.
Yeomans Bros. Co., 1423 Dayton St., Chicago, Ill.

Compressors, Air, Portable
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Chicago Pneumatic Tool Co., New York City.
Domestic Engine & Pump Co., Shippensburg, Pa.
Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.
Ingersoll-Rand Co., New York City.
Novo Engine Co., 220 Porter St., Lansing, Mich.
O. K. Clutch & Mach. Co., Columbia, Pa.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.
Yeomans Bros. Co., 1423 Dayton St., Chicago, Ill.

Compressors, Rotary
Yeomans Bros. Co., 1423 Dayton St., Chicago, Ill.

Concrete Breakers
Chicago Pneumatic Tool Co., New York.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Concrete, Curing
Dow Chemical Co., Midland, Mich.
Philadelphia Quartz Co., Philadelphia.
Semet-Solvay Co., 61 Broadway, New York, N. Y.

Concrete Heaters
Aeroil Burner Co., West New York, N. J.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Concrete Making Machinery
Koehring Company, Milwaukee, Wis.
Ransome Concrete Mchry. Co., Dunnellen, N. J.

Concrete Mixers
(See Mixers, Concrete.)

Concrete Pipe Machinery
Asphalto Concrete Corp., New York.

Concrete Placing Machinery
Insley Mfg. Co., Indianapolis, Ind.
Jaeger Machine Co., 222 Dublin Ave., Columbus, O.
Ransome Concrete Mach. Co., Dunnellen, N. J.

Concrete Proportioning Equipment
Dravo Equip. Co., Pittsburgh.

Concrete Reinforcement
American Steel & Wire Co., Chicago.
Concrete Steel Co., New York City.
Ryerson & Son, Joseph T., Chicago.
Truscon Steel Co., Youngstown, Pa.
Wickwire Spencer Steel Co., New York.

Concrete, Surface
Concrete Surfacing Machy. Co., Cincinnati, Ohio.

Condensers
Chicago Pneumatic Tool Co., New York.
Ingersoll-Rand Co., New York City.
Manistee Iron Works, Manistee, Mich.

Condensers, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
DeLaval Steam Turb. Co., Trenton, N. J.
Ingersoll-Rand Co., New York City.

Contractors
Cement Gun Constr. Co., Chicago.
Gunite Construction Co., Chicago.

Contractors, Diamond Drill Prospecting
Sullivan Machy. Co., 819 Wrigley Bldg., Chicago, Ill.

Conveyors, Belt
Allis-Chalmers Mfg. Co., Milwaukee.
Austin Western Rd. Mchy. Co., Chicago.
Barber-Greene Co., Aurora, Ill.
Galion Iron Works, Galion, O.
Good Roads Machinery Co., Kennett Square, Pa.
Haiss Mfg. Co., Inc., Geo., New York City.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Conveyors, Belt & Chain
Chain Belt Co., Milwaukee, Wis.
Haiss Mfg. Co., Geo., New York City.
Industrial Brownhoist Corp., Cleveland.

Conveyors, Brick
Haiss Mfg. Co., Geo., New York City.

Conveyors, Bucket
Haiss Mfg. Co., Inc., Geo., New York.
Industrial Brownhoist Corp., Cleveland.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.

Conveyors, Portable
Barber-Greene Co., Aurora, Ill.
Haiss Mfg. Co., Geo., New York City.

Conveyors, Units
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.

Coolers, Water
Everson Filter Co., 647 No. Green St., Chicago, Ill.

Corner Bead Metal
Concrete Steel Co., New York City.

Couplings, Threadless
Geo. H. Snell, Attleboro, Mass.

Couplings, (No Gasket)
Clark Co., H. W., Mattoon, Ill.

Couplings, Yokes (One Piece)
Clark Co., H. W., Mattoon, Ill.

Covers, Manhole
(See Manhole Covers)

Cranes, Crawling Tractor
Harnischfeger Corp., Milwaukee, Wis.
Koehring Company, Milwaukee, Wis.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, Ohio.
Thew Shovel Co., Lorain, Ohio.
Universal Crane Co., Lorain, Ohio.

Cranes, Creeper
Industrial Brownhoist Corp., Cleveland.

Cranes, Diesel
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Cranes, Electric
Harnischfeger Corp., Milwaukee, Wis.
Industrial Brownhoist Corp., Cleveland.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, O.
Thew Shovel Co., Lorain, Ohio.
Universal Crane Co., Lorain, Ohio.

Cranes, Gasoline
Buckeye Traction Ditcher Co., Findlay, Ohio.
Harnischfeger Corp., Milwaukee, Wis.
Industrial Brownhoist Corp., Cleveland.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, O.
Ohio Power Shovel Co., Lima, O.
Thew Shovel Co., Lorain, O.

Cranes, Jib
Harnischfeger Corp., Milwaukee, Wis.

Cranes, Locomotive
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Dredge Works, Bay City, Mich.
Bay City Foundry & Machine Co., Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
Byers Mch. Co., Ravenna, O.
Harnischfeger Corp., Milwaukee, Wis.
Insley Mfg. Co., Indianapolis, Ind.
Industrial Brownhoist Corp., Cleveland.
Koehring Co., Milwaukee, Wis.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, O
Orton Crane & Shovel Co., Chicago.
Osgood Company, Marion, O.
Speeder Machinery Co., Cedar Rapids, Ia.
Thew Shovel Co., Lorain, O.
Trackson Co., 533 Clinton St., Milwaukee.
Universal Crane Co., Lorain, O.

Cranes, Motor-Truck
Bay City Foundry & Machine Co., Bay City, Mich.
Byers Mch. Co., Ravenna, O.
Orton Crane & Shovel Co., Chicago, Ill.
Harnischfeger Corp., Milwaukee, Wis.
Universal Crane Co., Lorain, O.

Cranes, Overhead
Harnischfeger Corp., Milwaukee, Wis.

Cranes, Repair
Fulton Iron Works Co., St. Louis, Mo.

Cranes, Revolving
Page Engineering Co., Chicago, Ill.

Cranes, Road
Bucyrus-Erie Co., Erie, Pa.
The Byers Machine Co., Ravenna, O.

Cranes, Shovels
Manitowoc Engineering Wks., Manitowoc, Wis.

Cranes, Steam
Industrial Brownhoist Corp., Cleveland.
Thew Shovel Co., Lorain, O.

Cranes, Traveling
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Harnischfeger Corp., Milwaukee, Wis.
Industrial Brown Hoisting Co., Cleveland, O.
Speeder Machinery Corp., Cedar Rapids, Ia.

Cranes, Wrecking
Industrial Brown Hoisting Co., Cleveland, O.

Crawler Attachments
Haiss Mfg. Co., Inc., Geo., New York City.
Trackson Co., 533 Clinton St., Milwaukee, Wis.

Crimpers, Cap
E. I. DuPont de Nemours & Co., Wilmington, Del.

Crushers and Pulverizers
Allis-Chalmers Mfg. Co., Milwaukee.
Austin Western Rd. Mchy. Co., Chicago.
Bakstad Crusher & Equipment Corp., 122 S. Michigan Ave., Chicago, Ill.
Bay City Fdry. & Mch. Co., Bay City, Mich.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Iowa Manufacturing Co., Cedar Rapids, Ia.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Universal Road Machinery Co., Kingston, N. Y.
Wheeling Mold. & Fdy. Co., Wheeling, W. Va.
Western Wheeled Scraper Co., Aurora, Ill.

Crushers, Gyratory
Allis-Chalmers Mfg. Co., Milwaukee.
Austin Western Road Mach. Co., Chicago, Ill.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Crushers, Portable, with Elevator and Screens
Bakstad Crusher & Equipment Corp., 122 S. Michigan Ave., Chicago, Ill.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Iowa Manufacturing Co., Cedar Rapids, Ia.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Western Wheeled Scraper Co., Aurora, Ill.
Universal Road Machinery Co., Kingston, N. Y.

Crushers, Rock
Allis-Chalmers Mfg. Co., Milwaukee.
Austin Western Road Machinery Co., Chicago, Ill.
Bakstad Crusher & Equipment Corp., 122 S. Michigan Ave., Chicago, Ill.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Gruendler Patent Crusher & Pulverizer Co., St. Louis, Mo.
Iowa Mfg. Co., Cedar Rapids, Ia.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Universal Road Machinery Co., Kingston, N. Y.
Western Wheeled Scraper Co., Aurora, Ill.

Crushers, Repairs
Fulton Iron Works Co., St. Louis, Mo.

Culverts, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.
U. S. Cast Iron Pipe & Fdry. Co., Burlington, N. J.

Culverts, Corrugated
American Casting Co., Birmingham.
Armco Culvert Mfrs. Assn., Middletown, O.
Galion Iron Works, Galion, O.
Toncan Culvert Mfrs.' Assn., Massillon, O.

Culverts, Metal
Armco Culvert & Flume Mfrs. Assn., Middletown, O.
Austin Western Rd. Mchy. Co., Chicago.
U. S. Cast Iron Pipe & Fdy. Co., Birmingham, Ala.
R. D. Wood & Co., Philadelphia, Pa.

Culverts, Nestable & Riveted, Corrugated
Armco Culvert Mfrs. Assn., Middletown, O.
Toncan Culvert Mfrs.' Assn., Massillon, O.

Culvert Stock, Copper Alloy
Inland Steel Co., 38 South Dearborn St., Chicago, Ill.

Culverts
American Casting Co., Birmingham.
Burch Corporation, Crestline, Ohio.
Cast Iron Pipe Research Bureau, Chicago, Ill.
Galion Iron Works & Mfg. Co., Galion, Ohio.
Good Roads Mchy. Co., Inc., Kennett Square, Pa.
Klauer Mfg. Co., Dubuque, Ia.
Lock Joint Pipe Co., Ampere, N. J.
U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.
Wheeling Mold & Foundry Co., Wheeling, W. Va.

Cups, Suction & Force
Coleman, Allan, Chicago, Ill.

Curb Boxes
H. W. Clark Co., Mattoon, Ill.
Mueller Company, Decatur, Ill.
Reading Meter Repair Co., Reading, Pa.
S. E. T. Valve & Hydrant Co., New York, N. Y.

Curbs, Steel Protected
Concrete Steel Co., New York City.

Cutter, Gauge Glass
Coleman, Allan, Chicago, Ill.

Cutters, Asphalt
Chicago Pneumatic Tool Co., New York, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Dam Proofing
Philip Carey Company, Cincinnati, O.
Ceresit Waterproofing Co., Chicago, Ill.

Derrick Swingers
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Lidgerwood Mfg. Co., Elizabeth, N. J.

Derricks and Derrick Fittings
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Byers Mch. Co., Ravenna, Ohio.
Clyde Iron Works, Sales Co., Duluth, Minn.
Harnischfeger Corp., Milwaukee, Wis.
Hayward Co., New York City, N. Y.
Industrial Brown Hoisting Corp., Cleveland, O.
Insley Mfg. Co., Indianapolis, Ind.
Lidgerwood Mfg. Co., Elizabeth, N. J.

Diamond Floor Plates
Wood Steel Co., Allan, Conshohocken, Pa.

Diesel Engines
Chicago Pneumatic Tool Co., New York City.
Fairbanks-Morse & Co., Chicago.

Diggers, Trench and Clay
Chicago Pneumatic Tool Co., New York City.
Ingersoll-Rand Co., New York City.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Diggers, Pneumatic
Chicago Pneumatic Tool Co., New York City.
Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.

Diggers, Post Hole
Buda Company, Harvey, Ill.

Diggers, Trench
Buckeye Traction Ditcher Co., Findlay, Ohio.

Dip, Sewer & Basin
Coleman, Allan, Chicago, Ill.

Dipper Teeth
Western Crucible Steel Castings Co., Minneapolis, Minn.

Distributors, Pressure Oil
(See Road Oilers, Pressure)

Ditchers, Railway
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Industrial Brown Hoisting Corp., Cleveland, Ohio.
The Marion Steam Shovel Co., Marion, Ohio.

Ditching Machinery
(See Excavators.)

Dock Loading Machinery
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Drafting Machines
Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa.

Draglines
Bucyrus-Erie Company, Erie, Pa.
Harnischfeger Corp., Milwaukee, Wis.
Industrial Brownhoist Corp., Cleveland.
Koehring Company, Milwaukee, Wis.
Marion Steam Shovel Co., Marion, O.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.
Thew Shovel Co., Lorain, O.
Universal Crane Co., Lorain, O.

Drags, Road
J. D. Adams Co., Indianapolis, Ind.
Burch Corporation, Crestline, O.
Klauer Mfg. Co., Dubuque, Ia.
Western Wheeled Scraper Co., Aurora, Ill.

Drain Pipe
Armco Culvert Mfrs. Assn., Middletown, O.

Drain Traps
Clark Co., H. W., Mattoon, Ill.

Drainers, Cellar
The Economy Pumping Machy. Co., Chicago, Ill.

Drains, Perforated Iron
Armco Culvert Mfg. Assn., Middletown, Ohio.

Drawing Materials
Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa.

Drawing Tables
(See Tables and Bds. Drg.)

CLASSIFIED INDEX OF PRODUCTS

Dredges
Bay City Dredge Works, Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
Hayward Co., New York, N. Y.
Industrial Brown Hoisting Corp., Cleveland, O.
Lidgerwood Mfg. Co., Elizabeth, N. J.
The Marion Steam Shovel Co., Marion, Ohio.
Norborn Engineering Co., Darby, Pa.
Osgood Company, Marion, Ohio.

Dredges, Dipper
Bucyrus-Erie Company, Erie, Pa.
Erie Steam Shovel Co., Erie, Pa.
Harnischfeger Corp., Milwaukee, Wis.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Osgood Company, Marion, Ohio.

Dredges, Hydraulic
Bucyrus-Erie Company, Erie, Pa.
Marion Steam Shovel Co., Marion, O
The Norborn Engineering Co., Darby, Pa.

Drill Column & Mountings
Ingersoll-Rand Co., New York, N. Y.

Drilling, Contractors' Test
Sullivan Mach. Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Air
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Air Hammer
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Blasthole
Buda Company, Harvey, Ill.

Drills, Core
Ingersoll-Rand Co., New York City.
Keystone Driller Co., Beaver Falls, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Concrete
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Diamond Core Prospecting
Sullivan Mach. Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Earth
Buda Company, Harvey, Ill.
Schramm, Inc., West Chester, Pa.

Drills, Earth—Fence Post
Buda Company, Harvey, Ill.

Drills, Pavement, Core Test
Sullivan Machy. Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Posthole
Buda Company, Harvey, Ill.

Drills, Prospecting
Ingersoll-Rand Co., New York, N. Y.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drills, Railway Track
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Drills, Rock
Chicago Pneumatic Tool Co., New York City.
Ingersoll-Rand Co., New York City.
O. K. Clutch & Machy. Co., Columbia, Pa.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drill Sharpeners
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drill Steel, Furnaces
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drill Steel, Rock
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Drums, Counterweight
Hayward Co., New York City.

Drums, Holding
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Hayward Co., New York City.

Dry Chemical Feed Machines
Bacharach & Co., E. W., Kansas City, Mo.

Dryers
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Dryers, Sand, Portable
Aeroil Burner Co., Inc., West New York, N. J.
Connery & Co., Inc., 3996 N Second St., Philadelphia, Pa.
Jos. Honhorst Company, Cincinnati, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Dump Bodies
Anthony Co., Streator, Ill.
Hercules Products Co., Evansville, Ind.
Hughes-Keenan C., Mansfield, O.
Lee Trailer & Body Co., Plymouth, Ind.
Wood Hydraulic Hoist & Body Co., Detroit, Mich.

Dump Wagons
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Mchy. Co., Chicago.

Dust Control
The Barrett Co., New York, N. Y.
Dow Chemical Co., Midland, Mich.
Standard Oil Company, of Ind., Chicago, Ill.
Standard Oil Co. of N. Y., New York.
The Texas Company, New York, N. Y.

Dynamite
E. I. DuPont de Nemours & Co., Wilmington, Del.

Eaves, Trough
Klauer Mfg. Co., Dubuque, Ia.

Electric Display Fixtures
Everson Filter Co., 647 No. Green St., Chicago, Ill.

Elevators
Geo. Haiss Mfg. Co., Inc., New York.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Elevators, Bucket
Austin Western Rd. Mchy. Co., Chicago.
Haiss Mfg. Co., Inc., Geo., New York.
Industrial Brownhoist Corp., Cleveland.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Universal Road Machinery Co., Kingston, N. Y.

Elevators, Contractors' Material
Austin Western Rd. Mchy. Co., Chicago.
Byers Mch. Co., Ravenna, O.
Domestic Engine & Pump Co., Shippenburg, Pa.
Dravo Equipment Co., Pittsburgh.
Insley Mfg. Co., Indianapolis, Ind.
Ransome Concrete Mchry. Co., Dunnellen, N. J.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Elevators, Contractor Portable
O. K. Clutch & Machy. Co., Columbia, Pa.

Engineering Instruments
Buff & Buff Mfg. Co., Jamaica Plain, Mass.
Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa.

Engineers
(See Directory of Engineers.)
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Engineers' and Draftsmen's Instruments and Supplies
Kern Company, New York City.

Engines, Corliss
Fulton Iron Works Co., St. Louis, Mo.

Engines, Deep Well Pumping
American Well Works, Aurora, Ill.

Engines, Derrick Swinging
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.

Engines, Diesel
Allis-Chalmers Mfg. Co., Milwaukee.
Chicago Pneumatic Tool Co., New York.
Fairbanks Morse & Co., Chicago, Ill.
Fulton Iron Works Co., St. Louis, Mo.
Hercules Motors Corp., Canton, O.

Engines, Gas, Gasoline & Oil
Allis-Chalmers Mfg. Co., Milwaukee.
Buda Co., Harvey, Ill.
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Chicago Pneumatic Tool Co., New York.
Climax Engineering Co., Clinton, Ia.
Domestic Engine & Pump Co., Shippenburg, Pa.
Electric Wheel Co., Quincy, Ill.
Fairbanks, Morse & Co., Chicago, Ill.
Fulton Iron Works Co., St. Louis, Mo.
Ingersoll-Rand Co., New York, N. Y.
Novo Engine Co., 220 Porter St., Lansing, Mich.
Waukesha Motor Co., Waukesha, Wis.

Engines, Hoisting
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Clyde Iron Works Sales Co., Duluth, Minn.
Fairbanks Morse & Co., Chicago, Ill.

Engines, Kerosene
Chicago Pneumatic Tool Co., New York, N. Y.
International Harvester Co., of America, Chicago, Ill.

Engines, Oil
Allis-Chalmers Mfg. Co., Milwaukee.
Chicago Pneumatic Tool Co., New York, N. Y.
Fairbanks Morse & Co., Chicago, Ill.
Fulton Iron Works Co., St. Louis, Mo.
Ingersoll-Rand Co., New York, N. Y.

Engines, Portable
Novo Engine Co., 220 Porter St., Lansing, Mich.

Engines, Steam
Industrial Brownhoist Corp., Cleveland, Ohio.
Orr & Sembower, Reading, Pa.
Universal Road Machinery Co., Kingston, N. Y.

Engines, Steam Portable
Allis-Chalmers Mfg. Co., Milwaukee.

Equipment, Chlorine Control
Wallace & Tiernan, Newark, N. J.

Evaporators, Vacuum
Manistee Iron Works Co., Manistee, Mich.

Excavators, Bucket
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Dredge Works, Bay City, Mich.
Bucyrus-Erie Co., Erie, Pa.
Byers Machine Co., Ravenna, O.
Keystone Driller Co., Beaver Falls, Pa.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
The Marion Steam Shovel Co., Marion, Ohio.
Orton Crane & Shovel Co., Chicago, Ill.
The Thew Shovel Co., Lorain, O.

Excavator, Cableway
Lidgerwood Mfg. Co., Elizabeth, N. J.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.

Excavators, Crane
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Dredge Works, Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
Byers Machine Co., Ravenna, O.
The General Excavators Co., Marion, Ohio.
Industrial Brown Hoisting Corporation, Cleveland, O.
Koehring Company, Milwaukee, Wis.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
The Marion Steam Shovel Co., Marion, Ohio.
Orton Crane & Shovel Co., Chicago, Ill.
Speeder Machinery Corp., Cedar Rapids, Ia.
Thew Shovel Co., Lorain, O.
Universal Crane Company, Lorain, O.

Excavators, Curb
Buckeye Traction Ditcher Co., Findlay, Ohio.

Excavators, Ditch and Trench
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
The Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.
Bay City Dredge Works, Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
Byers Mch. Co., Ravenna, O.
Harnischfeger Corp., Milwaukee, Wis.
Hayward Co., New York, N. Y.
Industrial Brown Hoisting Corp., Cleveland, O.
Keystone Driller Co., Beaver Falls, Pa.
Koehring Company, Milwaukee, Wis.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, O.
Orton Crane & Shovel Co., Chicago, Ill.
Osgood Company, Marion, Ohio.
Thew Shovel Co., Lorain, O.
Universal Crane Co., Lorain, O.

Excavators, Dragline
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Dredge Works, Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
Byers Mch. Co., Ravenna, O.
The General Excavator Co., Marion, O.
Harnischfeger Corp., Milwaukee, Wis.
Hayward Co., New York City.
Industrial Brownhoist Corp., Cleveland.
Koehring Company, Milwaukee, Wis.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, Ohio.
Orton Crane & Shovel Co., Chicago, Ill.
Osgood Company, Marion, Ohio.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.
Speeder Machinery Corp., Cedar Rapids, Ia.
Thew Shovel Co., Lorain, O.
Universal Crane Co., Lorain, O.

Excavators, Power
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
The Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.
Bay City Dredge Works, Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
Byers Machine Co., Ravenna, O.
The General Excavators Co., Marion, Ohio.
Haiss Mfg. Co., Geo., New York City.
Industrial Brown Hoisting Corp., Cleveland, Ohio.
Keystone Driller Co., Beaver Falls, Pa.
Koehring Co., Milwaukee, Wis.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
The Marion Steam Shovel Co., Marion, Ohio.
Orton Crane & Shovel Co., Chicago, Ill.
Speeder Machinery Corp., Cedar Rapids, Ia.
The Thew Shovel Co., Lorain, O.
Universal Crane Co., Lorain, O.

Expanded Metal
Concrete Steel Co., New York City.
Ryerson & Son, Jos. T., Chicago, Ill.
Truscon Steel Co., Youngstown, Ohio.

Expansion Joints
Servicised Products Corp., Chicago, Ill.
Philip Carey Co., Cincinnati, O.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Explosives
E. I. DuPont de Nemours & Co., Wilmington, Del.

Fabric, Steel Reinforcing
American Steel & Wire Co., Chicago.
National Steel Fabric Co., Pittsburgh.
Joseph T. Ryerson & Son, Inc., Chicago, Ill.

Feed, Chemical
Wallace & Tiernan, Newark, N. J.

Feeders, Chemical
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Wallace & Tiernan, Newark, N. J.

Felt, Tarred
American Tar Products Corp., Pittsburgh, Pa.

Fence, Highway
American Steel & Wire Co., Chicago.
American Wire Fence Co., Chicago, Ill.
Page Steel & Wire Co., Bridgeport, Conn.
John A. Roebling's Sons Co., Trenton, N. J.
Wickwire Spencer Steel Co., New York.
Williamsport Wire Rope Co., Williamsport, Pa.

Fiber Sweeping Machines
Huntsville Fiber & Veneer Wks., Huntsville, Ala.

Filler, Asphalt
Philip Carey Co., Cincinnati, Ohio.
Kentucky Rock Asphalt Co., Louisville.
Standard Oil Co. of Ind., Chicago, Ill.
Standard Oil Co., of New York, New York, N. Y.
The Texas Company, New York, N. Y.

Fillers, Bituminous
American Tar Products Corp., Pittsburgh, Pa.
The Barrett Company, New York, N. Y.
Kentucky Rock Asphalt Co., Louisville.
Standard Oil Company of Indiana, Chicago, Ill.
Standard Oil Co. of New York, New York, N. Y.
Servicised Products Corp., Chicago, Ill.
The Texas Co., New York City.

Filtering Equipment
Bacharach & Co., E. W., Kansas City, Mo.
Everson Filter Co., 647 No. Green St., Chicago, Ill.

Filtering Systems
Bacharach & Co., E. W., Kansas City, Mo.
Everson Filter Co., 647 N. Green St., Chicago, Ill.

Filters, Water, Municipal and Industrial
Bacharach & Co., E. W., Kansas City, Mo.
Norwood Eng. Co., Florence, Mass.

Filter Agents
The Columbia Silica Co., 38 So. Dearborn St., Chicago, Ill.
Tamms Silica Co., Chicago.

Finishers, Bridges
Roughan Paving Gauge Co., Fond Du Lac., Wis.

Finishing Machines
A. W. French & Co., Chicago, Ill.
Heltzel Steel Form & Iron Co., Warren, O.

Fire Escapes
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Fireproofing Material & Construction
Concrete Steel Co., New York City.

Fish Traps
R. D. Wood & Co., Philadelphia, Pa.

Fittings
Crane Co., Chicago, Ill.

Fixtures, Electric Display
Everson Filter Co., 647 N. Green St., Chicago, Ill.

Fittings, Pipe Heavy
Fulton Iron Works Co., St. Louis, Mo.
U. S. Cast Iron Pipe & Fdry. Co., Burlington, N. J.

Fittings, Cast Iron
U. S. Cast Iron Pipe & Fdry. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Fixtures for Overhead Tanks, Stand Pipe or Water Crane Work
Fairbanks, Morse & Co., Chicago, Ill.

Floats, Rotary
Heltzel Steel Form & Iron Co., Warren, O.

CLASSIFIED INDEX OF PRODUCTS

Floor, Asphalt Mastic
Standard Oil Co. of Indiana, Chicago
Standard Oil Co. of N. Y., New York City.

Floor Finish
Ceresit Waterproofing Co., Chicago, Ill.

Floor Hardener, Concrete
(See Conc. Floor Hardener.)

Floor Plates
Central Iron & Steel Co., Harrisburg.
Wood Steel Co., Alan, Conshohocken, Pa.

Flooring, Fireproof
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Wood Steel Co., Alan, Conshohocken, Pa.

Flue Lining
Clay Products Assn., Chicago, Ill.

Flumes, Iron & Steel
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Klauer Mfg. Co., Dubuque, Ia.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Flush Tank, Syphons
Pacific Flush Tank Co., New York.

Flushers Hydraulic Sewer
Coleman, Allan, Chicago, Ill.
Peterson's Hydraulic Sewer Flusher Co., Milwaukee, Wis.

Flushers, Street
E. D. Entyre & Co., Inc., 63 Jefferson St., Oregon, Ill.

Fordson Attachments
Trackscon Co., Milwaukee, Wis.

Fordson Hoist Mountings
Clyde Iron Works Sales Co., Duluth.

Forges, Oil & Coke, Drill Steel
Ingersoll-Rand Co., New York, N. Y.

Forgings
Carnegie Steel Co., Pittsburgh, Pa.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Form Clamps
Insley Mfg. Co., Indianapolis, Ind.

Form Tighteners
Robert Bosch Mag. Co., Long Island City, N. Y.

Formgraders
Ted Carr Co., Chicago.

Forms, Concrete for Meter Boxes and Valve Housings
Clark Co., H. W., Mattoon, Ill.

Forms, Concrete Manhole
Clark Co., H. W., Mattoon, Ill.
Metal Forms Corp., Milwaukee, Wis.

Forms, for Concrete Meter Boxes
Clark Co., H. W., Mattoon, Ill.

Forms, Culvert, Road, Sewer, Tunnel
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

Forms for Curbs and Gutter
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Forms, Road & Sidewalk, Curb & Gutter
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Metal Forms Corp., Milwaukee, Wis.

Forms for Walls, Building Construction, etc.
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Metal Forms, Milwaukee, Wis.

Forms, Wood
National Lumber Mfrs. Assn., Washington, D. C.

Foundry Products, Misc.
Cast Iron Pipe Research Bureau, Chicago, Ill.
U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Fresnos
Galion Iron Works, Galion, O.

Frogs and Switches, Railway
Sweets Steel Co., Williamsport, Pa.

Furnaces, Compound Melting
Hauck Mfg. Co., Brooklyn, N. Y.

Furnaces, Lead Melting
Hauck Mfg. Co., Brooklyn, N. Y.
Jos. Honhorst Co., Cincinnati, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
The Leadite Co., Philadelphia, Pa.
Reading Meter Repair Co., Reading, Pa.

Furnaces, Oil Drill Steel
Ingersoll-Rand Co., New York, N. Y.
Sullivan Machy. Co., Chicago.

Fuse Detonating
E. I. DuPont de Nemours & Co., Wilmington, Del.

Fuse Safety
E. I. DuPont de Nemours & Co., Wilmington, Del.

Galvanometers, Blasting
E. I. DuPont de Nemours & Co., Wilmington, Del.

Garbage Disposal Apparatus
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Garbage Collection Wagons
Lee Trailer & Body Co., Chicago, Ill.

Gas Producers, Automatic
R. D. Wood & Co., Philadelphia.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Gaskets, Proof-Felt, Closet Bowl
Coleman, Allan, Chicago, Ill.

Gates, Bin
Allis-Chalmers Mfg. Co., Milwaukee.
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Butler Bin Co., Waukesha, Wis.
Good Roads Machy. Co., Inc., Kennett Square, Pa.
George Haiss Mfg. Co., Inc., New York, N. Y.
C. S. Johnson, Champaign, Ill.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Gates, Clam Shell
Haiss Mfg. Co., Geo., New York City.

Gates, Drainage
Armco Culvert & Flume Mfrs. Assn., Middletown, O.

Gates, Sluice
James B. Clow & Sons, 201-299 N. Talman Ave., Chicago, Ill.
Columbian Iron Works, Chattanooga.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Gate Valve Housing
Clark Co., H. W., Mattoon, Ill.
Reading Meter Repair Co., Reading, Pa.

Gauges, Depth
Republic Flow Meters Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Gauges, Elevated Tank
Clark Co., H. W., Mattoon, Ill.

Gauges, Loss of Head
Republic Flow Meters Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Gauges, Paving
Roughan Paving Gauge Co., Fond Du Lac, Wis.

Gauges, Rates of Flow
Republic Flow Meters Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Gauges, Recording
Clark Co., H. W., Mattoon, Ill.

Gauges, Surface Reservoir
Clark Co., H. W., Mattoon, Ill.

Gear, Reduction Units
Twin Disc Clutch Co., Racine, Wis.

Gears
Brown Lipe Gear Co., Syracuse, N. Y.
Foote Bros. Gear & Mach., Co., Chicago, Ill.
Haiss Mfg. Co., Geo., New York City.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Gears, Spur
Fulton Iron Works Co., St. Louis, Mo.

Gears, Worm Reduction
De Laval Steam Turbine Co., Trenton, N. J.

Gelatin, Blasting
E. I. DuPont de Nemours & Co., Wilmington, Del.

Generating Sets, Diesel Engine
Fairbanks-Morse & Co., Chicago, Ill.

Generators, Electric
Allis-Chalmers Mfg. Co., Milwaukee.
Bosch Mag. Co., Robert, N. Y. City.
Fairbanks-Morse Co., Chicago, Ill.

Grader Blades
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Mach. Co., Chicago, Ill.
Galion Iron Works, Galion, O.

Graders, Elevating
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Machy. Co., Chicago, Ill.
Western Wheeled Scraper Co., Aurora, Ill.

Graders, High Lift
Foote Bros. Gear & Mach. Co., Chicago, Ill.

Graders Road
Adams, J. D., Indianapolis, Ind.
Austin Western Rd. Machy. Co., Chicago, Ill.
The Galion Iron Works & Mfg. Co., Galion, O.
Good Rods Machy. Co., Inc., Kennett Square, Pa.
Highway Shoulder Co., Effingham, Ill.
Klauer Mfg. Co., Dubuque, Ia.
W. A. Riddell Co., Bucyrus, O.
Ryan Mfg. Corp., Chicago.
The Wehr Company, Milwaukee, Wis.
Western Wheeled Scraper Co., Aurora, Ill.

Graders, Road Power
J. D. Adams Co., Indianapolis, Ind.
Austin Mfg. Co., Chicago, Ill.
Galion Iron Works, Galion, O.
Good Roads Machy. Co., Kennett Square, Pa.
W. A. Riddell Co., Bucyrus, O.

Graders, Trail
Ted Carr & Co., Chicago, Ill.

Grapples, Stone
The Byers Machine Co., Ravenna, O.

Gratings, Flooring
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Gratings, Safety
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Gravel Equipment
Iowa Mfg. Co., Cedar Rapids, Ia.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.

Gravel Washing Plants
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.

Grinders, Air & Electric
Chicago Pneumatic Tool Co., New York.

Grinders, Pedestal
Ingersoll-Rand Co., New York, N. Y.

Grinders, Pneumatic Tool
Chicago Pneumatic Tool Co., New York.
Ingersoll-Rand Co., New York, N. Y.

Grizzlies, Rotary & Stationary
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Grouting
American Asphalt Grouting Co., Chattanooga, Tenn.
Dravo Contracting Co., Pittsburgh, Pa.

Guard, Highway
American Wire Fence Co., Chicago, Ill.
Maggart Corp., Chicago, Ill.
Page Steel & Wire Co., Bridgeport, Conn.
Wickwire Spencer Steel Co., New York City, N. Y.
Williamsport Wire Rope Co., Williamsport, Pa.

Gunite Construction
Cement Gun Constr. Co., Chicago.

Hammers, Calking
Chicago Pneumatic Tool Co., New York, N. Y.
Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.
Ingersoll-Rand Co., New York.
Schramm, Inc., West Chester, Pa.

Hammers, Chipping
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Hammers, Pile Driver
Industrial Brown-Hoist Corp., Cleveland, O.

Hammers, Pneumatic
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Hammers, Riveting
Chicago Pneumatic Tool Co., New York, N. Y.
Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Haydite—Aggregate
Hydraulic Press Brick Co., St. Louis, Mo.

Head Gates
American Casting Co., Birmingham, Ala.
Klauer Mfg. Co., Dubuque, Ia.

Headwalls
American Casting Co., Birmingham, Alabama.

Heaters, Asphalt Tool
Hauck Mfg. Co., Brooklyn, N. Y.

Heaters, Concrete
Hauck Mfg. Co., Brooklyn, N. Y.

Heaters & Dryers—Sand and Gravel
Jos. Honhorst Co., Cincinnati, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Heaters, Pavement Tool
Hauck Mfg. Co., Brooklyn, N. Y.

Heaters, Surface
Hauck Mfg. Co., Brooklyn, N. Y.

Heaters, Tar & Asphalt
Austin Western Machy. Co., Chicago.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
E. D. Entyre & Co., Inc., 63 Jefferson St., Oregon, Ill.
Hauck Mfg. Co., Brooklyn, N. Y.
Jos. Honhorst, Cincinnati, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Mohawk Asphalt Heater Co., Schenectady, N. Y.
Reading Motor Repair Co., Reading, Pa.
The Rightway Corporation, 228 N. La Salle St., Chicago, Ill.

Heaters, Concrete
Aeroil Burner Co., Union City, N. J.
E. D. Entyre & Co., Inc., 63 Jefferson St., Oregon, Ill.
Jos. Honhorst Co., Cincinnati, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Mohawk Asphalt Heater Co., Schenectady, N. Y.
Standard Steel Works, North Kansas City, Mo.

Heaters, Asphalt Tool
Jos. Honhorst Co., Cincinnati, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Heaters, Car
Klauer Mfg. Co., Dubuque, Ia.

Heaters, Pavement Tool
Aeroil Burner Co., Inc., West New York, N. J.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Heaters, Surface
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Heaters, Water
Aeroil Burner Co., Inc., Union Hill, N. J.
Central Foundry Co., New York, N. Y.
Hauck Mfg. Co., Brooklyn, N. Y.

Hemp, Braided
The Leadite Co., Philadelphia, Pa.

Highway Guard, Cable
American Steel & Wire Co., Chicago.
Cleveland Hardware Co., Cleveland, O.
Williamsport Wire Rope Co., Williamsport, Pa.

Highway, Mowers
Rawls Manufacturing Co., 202-210 Iowa Ave., Streator, Ill.

Hoes, Trench
Bucyrus-Erie Co., Erie, Pa.

Hoes, Patching, Asphalt
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Hoisting, Conveying Appliances
Industrial Brownhoist Corporation, Cleveland, O.

Hoists
Clyde Iron Works Sales Co., Duluth.
O. K. Clutch & Machinery Co., Columbia, Pa.
Sullivan Machy. Co., Chicago, Ill.

Hoists, Air Motor
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Lidgerwood Mfg. Co., Elizabeth, N. J.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Hoists, Belt
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.

Hoists, Cableway
Allis-Chalmers Mfg. Co., Milwaukee.
Domestic Engine & Pump Co., Shippensburg, Pa.
Lidgerwood Mfg. Co., Elizabeth, N. J.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.

Hoists, Concrete Tower
Insley Manufacturing Co., Indianapolis.
Lidgerwood Mfg. Co., Elizabeth, N. J.
O. K. Clutch & Mach. Co., Columbia, Pa.

Hoists, Contractors' Electric
Allis-Chalmers Mfg. Co., Milwaukee.
American Cement Machine Co., 251 E. Fourth St., Keokuk, Ia.
American Hoist & Derrick Co., St. Paul, Minn.
Bay City Dredge Works, Bay City.
Byers Machy. Co., Ravenna, O.
Domestic Engine & Pump Co., Shippensburg, Pa.
Fairbanks, Morse Co., Chicago, Ill.
Harnischfeger Corporation, Milwaukee.
Industrial Brownhoist Corporation, Cleveland, O.
Ingersoll-Rand Co., New York, N. Y.
Lidgerwood Mfg. Co., Elizabeth, N. J.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Novo Engine Co., 220 Porter St., Lansing Mich.
Sullivan Machy. Co., Chicago, Ill.
Wood Hydraulic Hoist & Body Co., Detroit, Mich.

Hoists, Contractors' Gasoline
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Domestic Engine & Pump Co., Shippensburg, Pa.
Harnischfeger Corp., Milwaukee.
Lidgerwood Mfg. Co., Elizabeth, N. J.
Novo Engine Co., 220 Porter St., Lansing, Mich.

CLASSIFIED INDEX OF PRODUCTS

Hoists, Contractors' Steam
Allis-Chalmers Mfg. Co., Milwaukee.
Byers Mch. Co., Ravenna, O.
Ingersoll-Rand Co., New York City.
Lidgerwood Mfg. Co., Elizabeth, N. J.
Orr & Sembower, Reading, Pa.

Hoists, Dragline Scraper
Allis-Chalmers Mfg. Co., Milwaukee.
Domestic Engine & Pump Co., Shippensburg, Pa.
Lidgerwood Mfg. Co., Elizabeth, N. J.
O. K. Clutch & Machy. Co., Columbia, Pa.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.
Sullivan Machy. Co., Chicago, Ill.

Hoists, Electric
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Fairbanks, Morse & Co., Chicago, Ill.
Harnischfeger Corp., Milwaukee, Wis.
Orr & Sembower, Reading, Pa.
Sullivan Machy. Co., Chicago, Ill.

Hoists, Gasoline
Clyde Iron Works, Duluth, Minn.
O. K. Clutch & Machy. Co., Columbia, Pa.
Orr & Sembower, New York.

Hoists, Geared
Allis-Chalmers Mfg. Co., Milwaukee.
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Chicago Pneumatic Tool Co., New York, N. Y.
Fairbanks, Morse & Co., Chicago, Ill.
O. K. Clutch & Machy. Co., Columbia, Pa.
Sullivan Machy. Co., Chicago, Ill.

Hoists, Hand
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Anthony Co., Inc., Streator, Ill.
Harnischfeger Corp., Milwaukee, Wis.

Hoists, Hydraulic
The Hughes-Keenan Co., Mansfield, O.
Hydraulic Hoist Mfg. Co., St. Paul
Wood Hydraulic Hoist & Body Co., Detroit, Mich.

Hoists, Material Tower
O. K. Clutch & Machy. C., Columbia, Pa.

Hoist, Mast
Insley Mfg. Co., Indianapolis, Ind.

Hoists, Motor Truck
Anthony Co., Inc., Streator, Ill.
The Galion Allsteel Body Co., Galion, Ohio.
The Hughes-Keenan Co., Mansfield, O.
Hydraulic Hoist Manufacturing Co., St. Paul, Minn.
Wood Hydraulic Hoist & Body Co., Detroit, Mich.

Hoists, Pneumatic
Chicago Pneumatic Tool Co., New York.
Ingersoll-Rand Co., New York City.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Hoists, Quarry
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Hoists, Scraper, Bucket
Allis-Chalmers Manufacturing Co., Milwaukee, Wis.
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
O. K. Clutch & Machy. Co., Columbia, Pa.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.
Sullivan Mach. Co., 819 Wrigley Bldg., Chicago, Ill.

Hoists, Scraper Loader
Allis-Chalmers Mfg. Co., Milwaukee.
Ingersoll-Rand Co., New York, N. Y.
O. K. Clutch & Machy. Co., Columbia, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Hoists, Skip
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Holders-on, Riveting
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.

Hoppers, Aggregate Measuring
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Butler Bin Co., Waukesha, Wis.
Geo. Haiss Mfg. Co., Inc., New York.
C. S. Johnson Co., Champaign, Ill.

Hoppers, Cast Iron
Fulton Iron Works, St. Louis, Mo.

Hoppers, Concrete
Insley Manufacturing Co., Indianapolis, Ind.
Ransome Concrete Mchry. Co., Dunnellen, N. J.

Hoppers, Concrete Tower
Ransome Concrete Mchy. Co., Dunellen, N. J.

Hoppers, Steel
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Butler Bin Co., Waukesha, Wis.
R. D. Cole Mfg. Co., Newman, Ga.
Johnson Company, C. S., Champaign, Ill.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Hose Clamps
Chicago Pneumatic Tool Co., New York, N. Y.

Hose Couplings
Chicago Pneumatic Tool Co., New York, N. Y.

Hose, Armored
Ingersoll-Rand Co., New York, N. Y.

Hose, Steam, Air, Water
Chicago Pneumatic Tool Co., New York.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Hydrants
The Bourbon Copper and Brass Works Co., 618-620 E. Front St., Cincinnati, Ohio.
Columbia Iron Works, Chattanooga, Tenn.
Darling Valve & Mfg. Co., Williamsport, Pa.
Wood & Co., R. D., Philadelphia, Pa.

Hydrants, Fire
The Bourbon Copper and Brass Works Co., 618-620 E. Front St., Cincinnati, Ohio.
Columbian Iron Works, Chattanooga, Tenn.
Fulton Iron Works Co., St. Louis, Mo.
R. D. Wood & Co., Philadelphia, Pa.

Hydrants, Self Closing
The Bourbon Copper and Brass Works Co., 618-620 E. Front St., Cincinnati, Ohio.

Hydraulic Machinery
R. D. Wood & Co., Philadelphia, Pa.

Hydraulic Packing
Mabbs Hydraulic Packing Co., Chicago, Ill.

Hydraulic Supplies
Reading Meter Repair Co., Reading, Pa.

Hydrogen Ion Equipment
La Motte Chemical Products Co., Baltimore, Md.

Incinerators
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Indicators (Chemical)
La Motte Chemical Products Co., Baltimore, Md.

Indicator Posts
R. D. Wood & Co., Philadelphia, Pa.

Inlets, Curb
H. W. Clark Company, Mattoon, Ill.
Klauer Mfg. Co., Dubuque, Ia.

Inserts, Concrete
Concrete Steel Co., New York City.

Inspecting Laboratories
(See Directory of Engineers.)

Instruments, Trouble-Finding
Clark Co., H. W., Mattoon, Ill.

Instruments & Drawing Supplies
Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa.

Instruments, Surveying
Buff & Buff Mfg. Co., Jamaica Plain, Boston, Mass.
Kern Company, New York City.

Inundators for Constant Concrete
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Irons, Branding
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.

Iron Works, Ornamental
The Hughes-Keenan Co., Mansfield, O.

Jacks, Pumping, Geared
American Manganese Bronze Co., Philadelphia, Pa.
American Well Works, Aurora, Ill.
Fairbanks Morse & Co., Chicago, Ill.

Joints, Expansion, Paving
W. R. Meadows, Elgin, Ill.
Servicized Products Corp., Chicago, Ill.

Joints, Filler Paving
Standard Oil Co. of Indiana, Chicago.
Standard Oil Co. of N. Y., New York.

Joints, Flexible Pipe
Central Foundry Co., New York City.
Geo. H. Snell, Attleboro, Mass.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Joint Installer
Roughan Pav. Gauge Co., Fond Du Lac, Wis.

Joists, Steel
Jos. T. Ryerson & Son, Inc., Chicago.

Kettles, Asphalt
Aeroil Burner Co., Inc., Union Hill, N. J.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Good Roads Mchy. Co., Inc., Kennett Square, Pa.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Kettles, Heating, Asphalt & Tar
Aeroil Burner Co., Inc., Union Hill, N. J.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Good Roads Mchy. Co., Inc., Kennett Square, Pa.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Universal Road Mchy. Co., Kingston, N. Y.

Kettles, Master
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.

Kettles, Pouring
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Kettles, Roofing
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Ladder Steps, Steel
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Ladles, Metal
H. W. Clark Company, Mattoon, Ill.
Reading Meter Repair Co., Reading, Pa.
The Leadite Company, Philadelphia, Pa.

Lanterns
Dietz Co., R. E., New York City.

Lath, Expanded Metal
Armco Culvert & Flume Mfrs. Assn., Middletown, O.
Concrete Steel Co., New York City.
Ryerson & Son, Jos. T., Chicago, Ill.

Leadite
Leadite Company, Philadelphia, Pa.

Leadite Melting Furnaces
Hauck Mfg. Co., Brooklyn, N. Y.

Lights, Contractors'
McCloskey Torch Co., Toledo, Ohio.
Toledo Pressed Steel Co., Toledo, O.

Lighting Plants, Contractors
Fairbanks Morse & Co., Chicago, Ill.

Loaders, Box Car
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.

Loaders, Buckets
Haiss Mfg. Co., Inc., Geo., New York.
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.
Trackson Co., 533 Clinton St., Milwaukee, Wis.

Loaders, Car and Wagon
Austin Western Rd. Mchy. Co., Chicago.
Barber-Greene Co., Aurora, Ill.
Burch Corp., Crestline, O.
Haiss Mfg. Co., Inc., Geo., New York.
Heltzel Steel Form & Iron Co., Warren, O.
Industrial Brownhoist Corp., Cleveland, Ohio.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.
Trackson Co., 533 Clinton St., Milwaukee, Wis.

Loaders, Coal
Atlas Engineering Co., Clintonville, Wis.
Central Foundry Co., New York, N. Y.
Geo. Haiss Mfg. Co., Inc., New York.

Loaders, Gravel & Sand
Atlas Engineering Co., Clintonville, Wis.
Geo. Haiss Mfg. Co., Inc., New York.
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.

Loaders, Portable
Atlas Engineering Co., Clintonville, Wis.
Bay City Dredge Works, Bay City, Mich.
Burch Corporation, Crestline, O.
Haiss Mfg. Co., Geo., New York City.
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.
Pioneer Gravel Equipment Mfg. Co., Minneapolis, Minn.

Loaders, Snow
Bay City Dredge Works, Bay City, Mich.
Haiss Mfg. Co., Inc., Geo., New York City, N. Y.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.
The Rightway Corporation, 228 N. La Salle St., Chicago, Ill.

Loaders, Truck
Atlas Engineering Co., Clintonville, Wis.
Bay City Dredge Works, Bay City, Mich.
Haiss Mfg. Co., Inc., Geo., New York City.
Heltzel Steel Form & Iron Co., Warren, O.
N. P. Nelson Iron Works, 821 Bloomfield Ave., Passaic, N. J.
Trackson Co., 533 Clinton St., Milwaukee, Wis.

Log Loaders
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
The Marion Steam Shovel Co., Marion, Ohio.

Logging Machinery
Lidgerwood Mfg. Co., New York, N. Y.

Lubricants
Standard Oil Co. of Ind., Chicago.
Standard Oil Co. of N. Y., New York.

Lumber, Creosoting
National Lumber Mfrs. Assn., Washington, D. C.

Lumber
National Lumber Mfrs. Assn., Washington, D. C.

Machinists, Contracting
Fulton Iron Works Co., St. Louis, Mo.

Machinery from Specail Designs and Machine Work to Order
Fulton Iron Works Co., St. Louis, Mo.

Magazines, Powder
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Magnetos
American Bosch Magneto Corp., Chicago.
Robert Bosch Mag. Co., Long Island City, N. Y.
Eisemann Magneto Co., New York City.

Maintainer, Road
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Mchy. Co., Chicago.
The Huber Mfg. Co., Marion, O.
The Hughes-Keenan Co., Mansfield, O.
The Wehr Company, Milwaukee, Wis.

Manhole Covers
Central Foundry Co., New York City.
H. W. Clark Company, Mattoon, Ill.
Wm. E. Dee Clay Mfg. Co., Chicago.
Fulton Iron Works Co., St. Louis, Mo.
Klauer Mfg. Co., Dubuque, Ia.
Reading Meter Repair Co., Reading, Pa.
South Bend Fdy. & Mach. Co., South Bend, Ind.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Manifolds, Rock Drill
Ingersoll-Rand Co., New York, N. Y.

Manilla Rope
(See Rope, Manilla.)

Manometers
Republic Flow Meter Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Marble & Slate Work
James B. Clow & Sons, 201-299 N. Talman Ave., Chicago, Ill.

Measuring, Pavement Roughness, Instrument
J. D. Adams Co., Indianapolis, Ind.

Mesh, Reinforcing Concrete
Inland Steel Co., 38 South Dearborn St., Chicago, Ill.

Meter Accessories
Badger Meter Mfg. Co., Milwaukee.
H. W. Clark Co., Mattoon, Ill.
Ford Meter Box Co., Wabash, Ind.

Meter Boxes
H. W. Clark Co., Mattoon, Ill.
Ford Meter Box Co., Wabash, Ind.
Reading Meter Repair Co., Reading, Pa.

Meter Connections
Geo. H. Snell, Attleboro, Mass.

Meter Housing
Clark Co., H. W., Mattoon, Ill.
Reading Meter Repair Co., Reading, Pa.

Meter Testers
H. W. Clark Co., Mattoon, Ill.

Meter Washers, Rawhide
Mabbs Hydraulic Packing Co., Chicago, Ill.

Meters, Jet
Badger Meter Mfg. Co., Milwaukee, Wis.

Meters, Oil
Badger Meter Mfg. Co., Milwaukee, Wis.
Republic Flow Meters Co., Chicago, Ill.

Meters, Pitot Tube
Republic Flow Meters Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Meter Repairs
Reading Meter Repair Co., Reading, Pa.

Meters, Sewage
Republic Flow Meters Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

CLASSIFIED INDEX OF PRODUCTS

Meters, Sewage (Venturi)
Simplex Valve & Meter Co., Philadelphia, Pa.

Meters, Venturi
Republic Flow Meters Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Meters, Water
Badger Meter Mfg. Co., Milwaukee, Wis.
Republic Flow Meter Co., Chicago, Ill.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Mixers, Asphalt
(See Mixers, Hot.)

Mixers, Concrete
American Cement Machine Co., 251 E. Fourth St., Keokuk, Ia.
Atlas Engineering Co., Clintonville, Wis.
Jaeger Machine Co., 222 Dublin Ave., Columbus, O.
Knickerbocker Co., Jackson, Mich.
Koehring Co., Milwaukee, Wis.
Orr & Sembower, Reading, Pa.
Ransome Concrete Mchy. Co., Dunellen, N. J.
The T. L. Smith Co., 1031 32nd St., Milwaukee, Wis.

Mixers, Grout
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Ransome Concrete Mchy. Co., Dunellen, N. J.
Smith Co., T. L. The, 1031 32nd St., Milwaukee, Wis.

Mixers, Chemical
The Dorr Co., New York City.

Mixers, Mortar
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Jaeger Machine Co., 222 Dublin Ave., Columbus, O.
Knickerbocker Co., Jackson, Mich.
Ransome Concrete Mchy. Co., Dunellen, N. J.
Smith Co., T. L. The, 1031 32nd St., Milwaukee, Wis.

Mixers, Paving
American Cement Machine Co., 251 E. Fourth St., Keokuk, Ia.
Construction Mchy. Co., Waterloo, Ia.
Jaeger Machine Co., 222 Dublin Ave., Columbus, O.
Koehring Company, Milwaukee, Wis.
Ransome Concrete Mchy. Co., Dunellen, N. J.
Smith Co., T. L. The, 1031 32nd St., Milwaukee, Wis.

Mixers, Pneumatic
Ransome Concrete Mchy. Co., Dunellen, N. J.

Mixer, Trailer
Lansing Co., Lansing, Mich.

Motors, Air
Ingersoll-Rand Co., New York, N. Y.

Motors, Centrifugal, Pump
Allis-Chalmers Mfg. Co., Milwaukee.

Motors, Electric
Allis-Chalmers Mfg. Co., Milwaukee.
Fairbanks, Morse & Co., Chicago, Ill.
Stearns Motor Mfg. Co., Ludington, Mich.

Motors, Gasoline
Buda Company, Harvey, Ill.
Climax Engineering Co., Clinton, Ia.
Continental Motors Corp., Muskegon, Mich.
Electric Wheel Co., Quincy, Ill.
Fairbanks, Morse & Co., Chicago, Ill.
Hercules Motors Corporation, Canton, Ohio.
Ingersoll-Rand Co., New York, N. Y.
Le Roi Company, Milwaukee, Wis.
Novo Engine Co., 220 Porter St., Lansing, Mich.
Waukesha Motor Co., Waukesha, Wis
Wisconsin Motor Mfg. Co., Milwaukee.

Motor Truck Accessories
Anthony Co., Inc., Streator, Ill.

Mountings, Truck Rubber Tires
Electric Wheel Co., Quincy, Ill.

Nozzles, Sewage
James B. Clow & Sons, 201-299 N. Talman Ave., Chicago, Ill.

Motor Trucks
(See Trucks, Motor.)

Mowers, Highway
Rawls Manufacturing Co., 202 210 Iowa Ave., Streator, Ill.

Oils, Road
American Tar Products Co., Pittsburgh, Pa.
Standard Oil Co. of Ind., Chicago, Ill.
Standard Oil Co. of New York, New York, N. Y.
The Barrett Company, New York, N. Y.
The Texas Company, New York, N. Y.

Oilers, Road Pressure
Austin Western Rd. Mchy. Co., Chicago, Ill.
Entyre & Co., Inc., E. D., 63 Jefferson St., Oregon, Ill.

Oilers, Rock Drill
Ingersoll-Rand Co., New York, N. Y.

Oils, Building
American Tar Products Corp., Pittsburgh, Pa.

Oils, Creosote
American Tar Products Corp., Pittsburgh, Pa.
Barrett Company, The, New York, N. Y.

Packing, Rawhide
Mabbs Hydraulic Packing Co., Chicago.

Paints—Industrial
Sement-Solvay Co., 61 Broadway, New York, N. Y.

Paint, Traffic
The Larrett Company, New York, N. Y.
Servicised Products Corp., Chicago, Ill.

Patch, Cold, Bit
American Tar Products Corp., Pittsburgh, Pa.
The Barrett Co., New York, N. Y.
Kentucky Rock Asphalt Co., Louisville.
Standard Oil Co. of Ind., Chicago, Ill.
Standard Oil Co. or N. Y., New York.
The Texas Company, New York, N. Y.

Patchers, Asphalt, Surface
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Pavements, Bituminous
American Tar Products Corp., Pittsburgh, Pa.
The Barrett Co., New York, N. Y.
Kentucky Rock Asphalt Co., Louisville.
Standard Oil Co. of Ind., Chicago, Ill.
Standard Oil Co. of New York, New York, N. Y.
The Texas Company, New York, N. Y.

Pavers
Foote Co., Nunda, N. Y.
Ransome Concrete Mchy. Co., Dunellen, N. J.
Smith Co., T. L. The, 1031 32nd St., Milwaukee, Wis.

Pavement Breakers
Chicago Pneumatic Tool Co., New York City.
Ingersoll-Rand Co., New York City.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Pavement Drills
Sullivan Mchy. Co., Chicago, Ill.

Paving, Asphalt
Standard Oil Co. of Ind., Chicago, Ill.
Standard Oil Co. of N. Y., New York.

Paving Blocks, Creosoted Wood
(See Creosoted Block Timber.)

Paving, Brick
National Paving Brick Mfrs. Assn., Chicago.

Paving, Cold Patching
Standard Oil Co. of Ind., Chicago, Ill.
Standard Oil Co. N. Y., New York.

Paving Materials, Vitrified Brick
National Paving Brick Mfrs. Assn., Chicago, Ill.

Penstocks
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
R. D. Cole Mfg., Co. Newman, Ga.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.

Pile Drivers
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Harnischfeger Corporation, Milwaukee.
Industrial Brownhoist Corp., Cleveland.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Pile Hammers, Steam
Industrial Brownhoist Corp., Cleveland, Ohio.

Piles, Screw
U. S. Cast Iron Pipe Fdy. Co., Burlington, N. J.

Piling, Steel Sheet
Carnegie Steel Co., Pittsburgh, Pa.
Wemlinger, Inc., New York City.

Pipe, Cast Iron
American Cast Iron Pipe Co., Birmingham, Ala.
Cast Iron Research Assn., Chicago.
Central Foundry Co., New York City.
Clow & Sons, James B., 201-299 N. Talman Ave., Chicago, Ill.
Copper and Brass Research Assn., New York City.
Fulton Iron Works Co. St. Louis, Mo.
McWane Cast Iron Pipe Co., Birmingham, Ala.
National Cast Iron Pipe Co., Birmingham, Ala.
Pacific States Cast Iron Pipe Co., Provo, Utah.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
Wood & Co., R. D., Philadelphia, Pa.

Pipe, Cast Iron Centrifugal
U. S. Cast Iron Pipe & Fdry. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Pipe, Cement Lined
American Cast Iron Pipe Co., Birmingham, Ala.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Pipe, Clay, Vitrified
Clay Products Assn., Chicago, Ill.

Pipe, Concrete
Asphalto-Concrete Corp., 1440 Broadway, New York, N. Y.
Independent Concrete Pipe Co., Indianapolis, Ind.
Lock Joint Pipe Co., Ampere, N. J.

Pipe, Conductor
Klauer Mfg. Co., Dubuque, Ia.
Wheeling Mold & Fdy. Co., Wheeling, W. Va.

Pipe Connections
Amer. Cast Iron Pipe Co., Birmingham.
Mueller Co., Decatur, Ill.
U. S. Cast Iron Pipe & Fry. Co., Burlington, N. J.

Pipe, Corrugated
Austin Western Rd. Mchy. Co., Chicago.

Pipe Cutter
Trimont Mfg. Co., Boston, Mass.
Tucker Co., Inc., The, 75 Murray St., New York, N. Y.

Pipe, Culvert
American Casting Co., Birmingham.
Independent Concrete Pipe Co., Indianapolis, Ind.
The Galion Iron Works, Galion, O.
Toncan Culvert Mfrs.' Ass'n., Massillon, O.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Pipe Covering (Asphalt)
Philip Carey Co., Cincinnati, O.

Pipe, deLavaud
U. S. Cast Iron Pipe & Fdry. Co., Burlington, N. J.

Pipe, Drain
American Cast Iron Pipe Co., Birmingham, Ala.
Asphalto-Concrete Corp., 1440 Broadway, New York, N. Y.
Central Foundry Co., New York, N. Y.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Pipe Drilling Machine
Mueller Co., Decatur, Ill.

Pipe Fittings
Amer. Cast Iron Pipe Co., Birmingham.
American Manganese Bronze Co., Philadelphia, Pa.
Central Foundry Co., New York City.
McWane Cast Iron Pipe Co., Birmingham, Ala.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Pipe and Fittings, Cast Iron
Amer. Cast Iron Pipe Co., Birmingham.
Cast Iron Pipe Research Bureau, Chicago, Ill.
Central Foundry Co., New York, N. Y.
McWane Cast Iron Pipe Co., Birmingham, Ala.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Pipe and Fittings, Flange
National Cast Iron Pipe Co., Birmingham, Ala.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Pipe Fusion, Welded
Kern Company, New York City.

Pipe—Gas Stopper
National Cast Iron Pipe Co., Birmingham, Ala.
Safety Gas Main Stopper Co., New York City.

Pipe, Hydraulic
Bourbon Copper and Brass Works Co., 618-620 E. Front St., Cincinnati, O.
Cast Iron Research Bureau, Chicago.
McWane Cast Iron Pipe Co., Birmingham.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Pipe—Independent
Independent Concrete Pipe Co., Indianapolis, Ind.

Pipe, Ingot Iron
Armco Culvert Mfrs. Assn., Middletown, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Pipe Joint Compounds
Leadite Co., Philadelphia, Pa.
Pacific Flush-Tank Co., 4241 Ravenswood Ave., Chicago, Ill. Also 9 Park Place, New York, N. Y.

Pipe Line Specialties
Crane Co., Chicago, Ill.
Reading Meter Repair Co., Reading, Pa.

Pipe Lines, Submerged
Cast Iron Pipe Research Bureau, Chicago, Ill.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Pipe Locators
Reading Meter Repair Co., Reading, Pa.

Pipe, Lock Joint
Lock Joint Pipe Co., Ampere, N. J.

Pipe Opener Chemical Compound
Coleman Allen, Chicago, Ill.

Pipe, Reinforced Concrete
Independent Concrete Pipe Co., Indianapolis, Ind.
Lock Joint Pipe Co., Ampere, N. J.

Pipe, Riveted Steel
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Pipe Seal
(See Pipe Joint Compounds.)

Pipe, Service
Cast Iron Pipe Research Bureau, Chicago, Ill.
Copper & Brass Research Assn., New York, N. Y.
Independent Concrete Pipe Co., Indianapolis, Ind.
McWane Cast Iron Pipe Co., Birmingham, Ala.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Pipe, Sewer
Asphalto-Concrete Corp., 1440 Broadway, New York.
Cast Iron Pipe Research Bureau, Chicaga, Ill.
Clay Products Co., Chicago, Ill.
Clow & Sons, James B., 201-299 N. Talman Ave., Chicago, Ill.
Dee Clay Mfg. Co., Wm. C., Chicago.
Independent Concrete Pipe Co., Indianapolis, Ind.
Lock Joint Pipe Co., Ampere, N. J.
Toncan Culvert Mfrs.' Ass'n., Massillon, O.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
Wheeling Mold & Fdy. Co., Wheeling, W. Va.
R. D. Wood & Co., Philadelphia, Pa.

Pipe, Spiral
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Pipe, Storm Sewer
Armco Culvert & Flume Ffrs. Assn., Middletown, O.
Independent Concrete Pipe Co., Indianapolis, Ind.
Toncan Culvert Mfrs.' Ass'n., Massillon, O.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Pipe Pushers
H. W. Clark Co., Mattoon, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Pipe, Water
National Cast Iron Pipe Co., Birmingham, Ala.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.

Piping, Industrial Plant
Cast Iron Pipe Research Bureau, Chicago, Ill.
U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.
R. D. Wood & Co., Philadelphia, Pa.

Planers, Subgrade
Koehring Co., Milwaukee, Wis.

Plants Municipal Filtration
Bacharach & Co., Kansas City, Mo.

Plants Chemical Treating
Bacharach & Co., Kansas City, Mo.

Plants, Electric
Kohler Co., Kohler, Wis.

Plaster, Cement
National Steel Fabric Co., Pittsburgh.

Plates, Annealed
Central Iron & Steel Company, Harrisburg, Pa.
Inland Steel Co., 38 South Dearborn St., Chicago, Ill.
Ryerson & Son, Inc., Jos. T., Chicago.
Alan Wood Steel Co., Conshohocken, Pa.

Plates, Cast Iron Manhole
Fulton Iron Works Co., St. Louis, Mo.

Plates, Floor
Alan Wood Steel Co., Conshohocken, Pa.
Central Iron & Steel Co., Harrisburg, Pa.,

Plates, Joint
Concrete Steel Co., New York, N. Y.

Plates, Sheared
Alan Wood Steel Co., Conshohocken, Pa.
Central Iron & Steel Co., Harrisburg, Pa.
Inland Steel Co., 38 South Dearborn St., Chicago,. Ill
Ryerson & Son, Inc., Jos. T., Chicago, Ill.

Plate Work
Alan Wood Steel Co., Conshohocken, Pa.
Central Iron & Steel Co., Harrisburg, Pa.
R. D. Cole Mfg. Co., Newman, Ga.
Jos. Honhorst Co., Cincinnati, O.
Littleford, Bros., 454 E. Pearl St., Cincinnati, O.

CLASSIFIED INDEX OF PRODUCTS

Plows, Grading
Adams Co., J. D., Indianapolis, Ind.
Austin Western Rd. Mchy. Co., Chicago, Ill.
Western Wheeled Scraper Co., Aurora, Ill.

Plows, Rooter
Adams Co., J. D., Indianapolis, Ind.
Austin Western Rd. Mchy. Co., Chicago, Ill.
Western Wheeled Scraper Co., Aurora, Ill.
W. A. Riddell Co., Bucyrus, O.

Plow, Snow
Adams Co., J. D., Indianapolis, Ind.
Austin Western Road Mchy. Co., Chicago, Ill.
Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.
E. D. Entyre & Co., Inc., 63 Jefferson St., Oregon, Ill.
Good Roads Mchy. Co., Inc., Kennett Square, Pa.
Klauer Mfg. Co., Dubuque, Ia.
Riddell Co., W. A., Bucyrus, O.
Rightway Corp., Chicago, Ill.
Wehr Company, Milwaukee, Wis.

Plows, Spreader
Bucyrus-Erie Company, Erie, Pa.

Plows, Unloading
Bucyrus-Erie Company, Erie, Pa.

Plumbing Fixtures
Mueller Company, Decatur, Ill.

Plumbing Supplies
Clow & Sons, James B., 201-299 N. Talman Ave., Chicago, Ill.
Mueller Company, Decatur, Ill.

Poles, Steel Structural
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Pools, Swimming
Bacharach & Co., E. W. Kansas City, Mo.
Everson Filter Co., 647 Green St., Chicago, Ill.

Post and Hole Machinery
Buda Company, Harvey, Ill.

Post, Fence
American Steel & Wire Co., Chicago, Ill.
Inland Steel Co., 38 South Dearborn St., Chicago, Ill.

Posts, Indicator Valve
R. D. Wood & Co., Philadelphia, Pa.

Posts and Kettles
H. W. Clark Co., Mattoon, Ill.
The Leadite Company, Philadelphia, Pa.

Posts, Lamp, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.

Poultry Netting
American Steel & Wire Co., Chicago, Ill.

Pouring, Gates
Leadite Company, The, Philadelphia, Pa.

Pouring Pots
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Powder, Blasting
E. I. DuPont de Nemours & Co., Wilmington, Del.

Powder, Railroad
E. I. DuPont de Nemours & Co., Wilmington, Del.

Power Heads
Fairbanks Morse & Co., Chicago, Ill.

Power Units, Gasoline
Buda Company, Harvey, Ill.
Climax Engineering Co., Clinton, Ia.
Continental Motors Corp., Detroit.
Electric Wheel Co., Quincy, Ill.
Hercules Motors Corp., Canton, O.
LeRoi Company, Milwaukee, Wis.
Novo Engine Co., 220 Porter St., Lansing, Mich.
Waukesha Motor Co., Waukesha, Wis.
Wisconsin Motor Mfg. Co., Milwaukee.

Power Units Takeoff
Twin Disc Clutch Co., Racine, Wis.

Pressed Steel Products
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Pressure Regulators
H. W. Clark Co., Mattoon, Ill.

Producers, Gas
R. D. Wood & Co., Philadelphia, Pa.

Pulleys, Clutch
Twin Disc Clutch Co., Racine, Wis.

Pumping Plants, Sewage
Economy Pumping Machy. Co., Chicago, Ill.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Pump and Engine, Combined
(With Oil Engine.)
Fulton Iron Wks., St. Louis, Mo.

Pump Parts, Rod
Fulton Iron Works Co., St. Louis, Mo.

Pump, Suction and Force
American Well Works, Aurora, Ill.
Coleman, Allan, Chicago, Ill.

Pumps, Air
Chicago Pneumatic Tool Co., 6 East 44th St., New York City.
Ingersoll-Rand Co., New York, N. Y.
Manistee Iron Works, Manistee, Mich.

Pumps, Air Lift
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.
Yeomans Bros. Co., 1423 Dayton St., Chicago, Ill.

Pumps, Artesian Well
American Well Works, Aurora, Ill.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Pumps, Bilge
The Economy Pumping Mchy. Co., Chicago, Ill.
Fairbanks Morse & Co., Chicago, Ill.
Manistee Iron Works, Manistee, Mich.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Pumps, Boiler Feed, Steam
Allis-Chalmers Mfg. Co., Milwaukee.
Cameron Steam Pump Wks., A. S. (Ingersoll-Rand Co.), New York City.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), New York City.
Manistee Iron Works, Manistee, Mich.

Pumps, Centrifugal
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
Byron Jackson Pump Co., Berkeley, Calif.
The Barnes Mfg. Co., 931 Main St., Mansfield, O.
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Dayton-Dowd Co., Quincy, Ill.
DeLaval Steam Turbine Co., Trenton, N. J.
Domestic Engine & Pump Co., Shippensburg, Pa.
The Economy Pumping Mchy. Co., Chicago, Ill.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Layne & Bowler Co., Memphis, Tenn.
Manistee Iron Works, Manistee, Mich.
Peerless Pump Co., Los Angeles, Calif.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Pumps, Centrifugal and Multi-Stage High Lift
American Well Works, Aurora, Ill.
Cameron Steam Pump Wks., A. S. (Ingersoll-Rand Co.), New York City.
DeLaval Steam Turbine Co., Trenton, N. J.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), New York City.
Keystone Driller Co., Beaver Falls, Pa.
Manistee Iron Works, Manistee, Mich.
Novo Engine Co., 220 Porter St., Lansing, Mich.

Pumps, Contractors'
American Well Works, Aurora, Ill.
The Barnes Co., 931 Main St., Mansfield, O.
Blackmer Pump Co., Grand Rapids, Mich.
Cameron Steam Pump Works, A. S. Ingersoll-Rand Co., New York.
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Domestic Engine & Pump Co., Shippensburg, Pa.
Fairbanks, Morse & Co., Chicago, Ill.
Ingersoll-Rand Co. A. S. Cameron Steam Pump Works), New York.
Novo Engine Co., 220 Porter St., Lansing, Mich.
Yeomans Brcs. Co., 1423 Dayton St., Chicago, Ill.

Pumps, Deepwell
Allis-Chalmers Mfg. Co., Milwaukee.
Amr. Well Works, Aurora, Ill.
Byron Jackson Pump Co., Berkeley, Calif.
DeLaval Steam Turbine Co., Trenton, N. J.
Domestic Engine & Pump Co., Shippensburg, Pa.
The Economy Pumping Mchy. Co., Chicago, Ill.
Fairbanks Morse & Co., Chicago, Ill.
Keystone Driller Co., Beaver Falls, Pa.
Layne & Bowler Co., Memphis, Tenn.
Novo Engine Co., 220 Porter St., Lansing, Mich.
Peerless Pump Co., Los Angeles, Calif.
United Iron Works, Kansas City, Mo.

Pumps, Diaphragm
The Barnes Mfg. Co., 931 Main St., Mansfield, O.
Domestic Engine & Pump Co., Shippensburg, Pa.
Novo Engine Co., 220 Porter St., Lansing, Mich.

Pumps, Drainage
The Barnes Mfg. Co., 931 Main St., Mansfield, O.
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Ingersoll-Rand Co., New York, N. Y.
Economy Pump Machy. Co., Chicago, Ill.
Manistee Iron Wks., Manistee, Mich.
Yeomans Bros. Co., 1423 Dayton St., Chicago, Ill.

Pumps, Dredging and Sand
Marion Steam Shovel Co., Marion, O.
Norborn Engineering Co., Darby, Pa.

Pumps, Electric
Allis-Chalmers Mfg. Co., Milwaukee.
Manistee Iron Wks., Manistee, Mich.
Yeomans Bros. Co., 1423 Dayton St., Chicago, Ill.

Pumps, Fire Service
Allis-Chalmers Mfg. Co., Milwaukee.
American Well Works, Aurora, Ill.
Manistee Iron Works Co., Manistee, Mich.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Pumps, Force
Aeroil Burner Co., Allentown, Pa.
The Barnes Mfg. Co., 931 Main St., Mansfield, O.
Domestic Engine & Pump Co., Shippensburg, Pa.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.

Pumps, Gasoline and Oil
Manistee Iron Wks., Manistee, Mich.

Pumps, Hand
Domestic Engine & Pump Co., Shippensburg, Pa.

Pumps, Multistage High Lift
Allis-Chalmers Mfg. Co., Milwaukee.
Manistee Iron Wks., Manistee, Mich.

Pumps, Piston
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co., New York City.

Pumps, Plunger
The Barnes Mfg. Co., 931 Main St., Mansfield, O.

Pumps, Power
American Well Works, Aurora, Ill.
United Iron Works, Kansas City, Mo.

Pumps, Pumping, Centrifugal and Multi-Stage High Lift
Economy Pumping Machy. Co., Chicago, Ill.

Pumps, Quarry
American Well Works, Aurora, Ill.

Pumps, Reclamation
American Well Works, Aurora, Ill.

Pumps, Road Builders
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Domestic Engine & Pump Co., Shippensburg, Pa.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Novo Engine Co., 220 Porter St., Lansing, Mich.

Pumps, Rotary
Blackmer Pump Co., Grand Rapids, Mich.
Yeomans Brcs. Co., 1423 Dayton St., Chicago, Ill.

Pumps, Sewage
Allis-Chalmers Mfg. Co., Milwaukee.
American Well Works, Aurora, Ill.
Economy Pump Machy. Co., Chicago, Ill.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Pacific Flush-Tank Co., 4241 Ravenswood Ave., Chicago, Ill. Also 9 Park Place, New York, N. Y.
Yeomans Bros. Co., 1423 Dayton St., Chicago, Ill.

Pumps, Sinking
American Well Works, Aurora, Ill.
Manistee Iron Wks., Manistee, Mich.

Pumps, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
Fairbanks Morse & Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.

Pumps, Sump
American Well Works, Aurora, Ill.
Economy Pump Machy. Co., Chicago, Ill.
Fairbanks Morse & Co., Chicago, Ill.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Pumps, Trench Portable
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Domestic Engine & Pump Co., Shippensburg, Pa.

Pumps, Triplex
The Economy Pumping Mchy. Co., Chicago, Ill.
C. H. & E. Manufacturing Co., Milwaukee, Wis.
Domestic Engine & Pump Co., Shippensburg, Pa.
Fairbanks Morse & Co., Chicago, Ill.

Pumps, Turbine
Allis-Chalmers Mfg. Co., Milwaukee.
American Well Works, Aurora, Ill.
Manistee Iron Wks., Manistee, Mich.
Peerless Pump Co., Los Angeles, Calif.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Pumps, Underwriters' Centrifugal
Allis-Chalmers Mfg. Co., Milwaukee.
American Well Works, Aurora, Ill.

Pumps, Vacuum
Manistee Iron Works Co., Manistee, Mich.
Chicago Pneumatic Tool Co., New York.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Pumps, Water Works
Allis-Chalmers Mfg. Co., Milwaukee.
American Well Works, Aurora, Ill.
Chicago Pneumatic Tool Co., New York.
DeLaval Steam Turbine Co., Trenton, N. J.
Domestic Engine & Pump Co., Shippensburg, Pa.
Economy Pump Machy. Co., Chicago, Illinois.
Manistee Iron Wks., Manistee, Mich.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Punches, Shank and Bit
Ingersoll-Rand Co., New York, N. Y.

Radiators
Modine Mfg. Co., Racine, Wis.
Young Radiator Co., Racine, Wis.

Railroad Ditchers
Bucyrus-Erie Co., Erie, Pa.
Harnischfeger Corporation, Milwaukee.
Marion Steam Shovel Co., Marion, O.

Rail and Rail Joints
Sweet's Steel Co., Williamsport, Pa.

Railings, Ornamental
The Hughes-Keenan Co., Mansfield, O.

Rails, Relaying
(See Clearing House.)

Rails, Road
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Metal Forms Corp., Milwaukee, Wis.

Ralls, Steel
Inland Steel Co., 38 South Dearborn St., Chicago, Ill.

Railway Supplies
Chicago Pneumatic Tool Co., New York, N. Y.
Sweet's Steel Co., Williamsport, Pa.

Railways, Industrial and Portable
Sweet's Steel Co., Williamsport, Pa.

Rakes, Asphalt
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Rammers, Pneumatic
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Ready-Built Buildings
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Receivers, Air
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Mchy. Co., Chicago, Ill.

Recorders, Portable Pitot
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Reheaters, Air
Ingersoll-Rand Co., New York, N. Y.

Reinforcing Concrete
(See Concrete Reinforcement.)

Reinforcing Metal for Concrete Work
American Steel & Wire Co., Chicago.
Concrete Steel Co., New York City.
Ryerson & Son, Jos. T., Chicago, Ill.

Rings, Lamphole
Klauer Mfg. Co., Dubuque, Ia.

Rivet Busters and Sets
Chicago Pneumatic Tool Co., New York.
Ingersoll-Rand Co., New York, N. Y.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Riveting Machines
Chicago Pneumatic Tool Co., New York.

Rivet Heaters, Electric
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.

Rivet Heaters, Oil
Hauck Mfg. Co., Brooklyn, N. Y.

Rivets
Ryerson & Son, Inc., Jos. T., Chicago, Ill.

Road Finisher
A. W. French & Co., Chicago.

Road Finishing Machines
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

CLASSIFIED INDEX OF PRODUCTS

Road Machinery Parts
J. D. Adams Co., Indianapolis, Ind.
French & Hecht Company, Davenport, Ia.
Galion Iron Works & Mfg. Co., Galion, O.

Road Oils and Preservatives
Solvay Process Company, New York.
Standard Oil Co. of Indiana, Chicago.
Standard Oil Co. of N. Y., New York.

Road Oilers, Pressure
Austin Western Road Machinery Co., Chicago, Ill.
Good Roads Machinery Co., Kennett Square, Pa.

Road Rollers, Gas and Steam
Austin Western Road Machinery Co., Chicago, Ill.
Buffalo-Springfield Roller Co., Springfield, O.

Road Rooter
Ted Carr & Co., Chicago, Ill.
Erie Machine Shops, Erie, Pa.
Entyre & Co., Inc., E. D., 63 Jefferson St., Oregon, Ill.
Galion Iron Works, Galion, O.
Huber Mfg. Co., Marion, O.

Road Sprinkler
Galion Iron Works & Mfg. Co., Galion, O.

Rock Drill, Accessories
Chicago Pneumatic Tool Co., New York, N. Y.
Sullivan Mchy. Co., Chicago, Ill.

Rods, Sewer & Conduit
Coleman, Allan, Chicago, Ill.

Rods, Wire
American Steel & Wire Co., Chicago.

Rollers, Road
Austin Western Road Machinery Co., Chicago, Ill.
Buffalo-Springfield Roller Co., Springfield, O.
Erie Machine Shops, Erie, Pa.
Galion Iron Works & Mfg. Co., Galion, O.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Huber Mfg. Co., Marion, O.
W. A. Riddell Co., Bucyrus, Ohio.
Universal Road Machinery Co., Kingston, N. Y.
Wehr Company, Milwaukee, Wis.

Rollers, Road, Gasoline
(See Road Rollers.)

Rollers, Road, Horse Drawn
Huber Mfg. Co., Marion, O.

Rollers, Road, Steam
Austin Western Road Machinery Co., Chicago, Ill.
Buffalo-Springfield Roller Co., Springfield, O.
Erie Machine Shops, Erie, Pa.
Huber Mfg. Co., Marion, Ohio.

Rollers, Road, Tandem
Austin Western Road Machinery Co., Chicago, Ill.
Buffalo-Springfield Roller Co., Springfield, O.
Erie Machine Shops, Erie, Pa.
Huber Mfg. Co., Marion, Ohio.

Rollers, Road, Tandem, Steam
(See Rollers, Road Horse Drawn.)

Rolls, Crushing
Allis-Chalmers Mfg. Co., Milwaukee.

Rolls, Grinding, for Various Purposes
Fulton Iron Works Co., St. Louis, Mo.

Roofing (All Kinds)
Carey Company, Philip, Cincinnati, O.
Klauer Mfg. Co., Dubuque, Ia.

Roofing Metal
Ryerson & Son, Inc., Joseph T., Chicago, Ill.

Roofing, Pitch
American Tar Products Co., Pittsburgh.

Roofers
Adams Co., J. D., Indianapolis, Ind.
Ted Carr & Co., Chicago, Ill.

Rope, Wire, Fittings
Maggart Corporation, Chicago, Ill.
Roebling, John A., & Sons Co., Trenton, N. J.

Rope, Wire, Transmission Hoisting or Haulage
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
American Steel & Wire Co., Chicago.
Hazard Wire Rope Co., Wilkes-Barre, Pa.
Page Steel & Wire Co., Bridgeport, Conn.
Roeblings Sons Co., J. A., Trenton, N. J.
Wickwire Spencer Steel Co., New York.
Williamsport Wire Rope, Williamsport, Pa.

Runners, Lock Joint
Coleman, Allan, Chicago, Ill.

Runners, Turbine
American Manganese Bronze Co., Philadelphia, Pa.

Salamanders
Aeroil Burner Co., Inc., Union Hill, N. J.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Sand and Gravel Handling Machines
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.

Sand and Graveling Plant
Columbia Silica Co., Akron, Ohio.
Northern Gravel Co., Muscatine, Ia.

Sand Blast Sand
The Columbia Silica Co., 38 So. Dearborn St., Chicago, Ill.

Sand Filtration
The Columbia Silica Co., 38 So. Dearborn St., Chicago, Ill.
Northern Gravel Co., Muscatine, Ia.
Tamms Silica Co., Chicago, Ill.

"Sand Spun" Pipe
R. D. Wood & Co., Philadelphia, Pa

Sash, Steel
Ryerson Steel Co., Chicago.

Saws, Rigs, Portable
C. H. & E. Manufacturing Co., Milwaukee, Wis
Knickerbocker Co., Jackson, Mich.

Saws, Rail
Industrial Brownhoist Corp., Cleveland.

Scaffolding, Steel Tubular
Patent Scaffolding Co., New York City.

Scaffolds—Swinging, All Types
Patent Scaffolding Co., New York City.

Scales, All Kinds
Fairbanks, Morse & Co., Chicago, Ill.

Scales for Meter Testers
Clark Co., H. W., Mattoon, Ill.

Scarifiers
Ted Carr Co., Chicago, Ill.
Killefer Mfg. Co., Los Angeles, Calif.
Western Wheeled Scraper Co., Aurora, Ill.

Scarifiers and Road Graders
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Mchy. Co., Chicago, Ill.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
W. A. Riddell Co., Bucyrus, O.
Wehr Co.; Milwaukee, Wis.
Western Wheeled Scraper Co., Aurora, Ill.

Schools & Colleges
(See Directory of Engineers.)

Scrapers, Drag
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Machinery Co., Chicago, Ill.
L. P. Green, Chicago, Ill.
Western Wheeled Scraper Co., Aurora, Ill.

Scrapers, Drag, Power
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.

Scrapers, Dragline
Garst Mfg. Company, Chicago, Ill.
Sauerman Brothers, Inc., 438 S. Clinton St., Chicago, Ill.

Scrapers, Fresno
J. D. Adams Co., Indianapolis, Ind.
Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.
Klauer Mfg. Co., Dubuque, Ia.
Western Wheeled Scraper Co., Aurora, Ill.

Scrapers, Four-Wheel, Self-Loading
J. D. Adams Co., Indianapolis, Ind.
Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.

Scrapers, Mormon
J. D. Adams Co., Indianapolis, Ind.

Scrapers, Power Plow
Garst Mfg. Co., Chicago, Ill.

Scrapers, Scarifiers, Plows, Etc.
J. D. Adams Co., Indianapolis, Ind.
Anthony Co., Streator, Ill.
Austin Western Road Machinery Co., Chicago, Ill.
Ted Carr Co., Chicago, Ill.
Killifer Mfg. Co., Los Angeles, Calif.
Multifoote Co., Nunda, N. Y.
Roderick Lean Co., Mansfield, O.
Speeder Mchy. Corp., Cedar Rapids, Ia.
Western Wheel Scraper Co., Aurora, Ill.

Scrapers, Slip
J. D. Adams Co., Indianapolis, Ind.
Burch Corporation, Crestline, O.

Scrapers, Wheel
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Machinery Co., Chicago, Ill.
Galion Iron Works, Galion, O.
Western Wheeled Scraper Co., Aurora, Ill.

Screening Plants, Sand and Gravel
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Western Wheeled Scraper Co., Aurora, Ill.

Screens, Conical Revolving
Allis-Chalmers Mfg. Co., Milwaukee.

Screens, Gravel Washing
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Screens, Intake
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Screens, Revolving
Austin Western Road Machinery Co., Chicago, Ill.
Converse Co., Inc., Johnson City, N. Y.
Haiss Mfg. Co., Geo., New York City.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Pioneer Gravel Equipment-Mfg. Co., Minneapolis, Minn.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Universal Road Machinery Co., Kingston, N. Y.

Screens, Sand, Gravel and Coal
Austin Western Road Machinery Co., Chicago, Ill.

Screens, Shaker
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Haiss Mfg. Co., Inc., Geo., New York.
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Pioneer Gravel Equipment-Mfg. Co., Minneapolis, Minn.
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Western Wheeled Scraper Co., Aurora, Ill.
Wickwire Spencer Steel Co., New York.

Screens, Stone
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.
Universal Crusher Co., Cedar Rapids, Ia.

Screens, Water Intake
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Screens, Well
Layne & Bowler Co., Memphis, Tenn.

Segment Blocks
Clay Products Assn., Chicago, Ill.

Service Boxes
Clark Co., H. W., Mattoon, Ill.
Mueller Company, Decatur, Ill.

Second-Hand Equipment
(See Clearing Section.)

Sewage Disposal Apparatus
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Pacific Flush-Tank Co., 4241 Ravenswood Ave., Chicago, Ill. Also 9 Park Place, New York, N. Y.

Sewage Ejectors
The Economy Pumping Machy. Co., Chicago, Ill.
Yeomans Brothers Co., 1423 Dayton St., Chicago, Ill.

Sewer and Basin Dips
Coleman, Allan J., Chicago, Ill.

Sewer Flushers or Plugs
Petersens Hydraulic Sewer Flusher Co., Milwaukee, Wis.

Sewer, Joint Compounds
Pacific Flush-Tank Co., 4241 Ravenswood Ave., Chicago, Ill. Also 9 Park Place, New York N. Y.
Reading Meter Repair Co., Reading, Pa.

Sewer Rods Flat Wire
Coleman, Allan, Chicago, Ill.

Sewers Storm
Armco Culvert Mfrs. Assn., Middletown, O.

Shaft Caps
American Manganese Bronze Co., Philadelphia, Pa.

Shanking Machines, Drill Steel
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machy. Co., Chicago, Ill.

Sharpeners, Rock, Drill, Steel
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Sharpening Machines Drill Bit
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Sheathing Paper
Philip Carey Co., Cincinnati, O.

Sheaves
Haiss Mfg. Co., Inc., Geo., New York.
Western Block Co., Lockport, N. Y.
Williamsport Wire Rope Co., Williamsport, Pa.

Sheet Metal Products
Klauer Mfg. Co., Dubuque, Ia.

Sheets, Iron and Steel
Ryerson & Son, Joseph T., Chicago.

Sheets, Roofing and Siding
Armco Culvert Mfrs. Assn., Middletown, O.
Ryerson & Son, Joseph T., Chicago, Ill.

Shingles, Asphalt
Carey Co., Philip, The, Cincinnati, O.

Shoulder Machines
Highway Shoulder Co., Effingham, Ill.

Shovel (Power) Parts
General Excavators Co., Marion, O.
Ohio Power Shovel Co., Lima, O.

Shovels, Asphalt
General Excavators Co., Marion, O.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Shovels, Crawling Tractors
Thew Shovel Co., Lorain, O.

Shovels, Creeper
Harnischfeger Corporation, Milwaukee, Wis.
Industrial Brownhoist Corp., Cleveland, O.

Shovels, Diesel
Bucyrus-Erie Company, Erie, Pa.
Harnischfeger Corporation, Milwaukee, Wis.
Industrial Brownhoist Corp., Cleveland, O.

Shovels, Electric
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Dredge Works, Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
Harnischfeger Corporation, Milwaukee.
Industrial Brownhoist Corp., Cleveland.
Keystone Driller Co., Beaver Falls, Pa.
Link Belt Co., 2045 W. Hunting Park Ave. Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co. Marion, O.
The Osgood Co., Marion, O.
Thew Shovel Co., Lorain O.

Shovels Electric Crawler
Harnischfeger Corp., Milwaukee, Wis.

Shovels, Fordson
Insley Mfg. Co., Indianapolis Ind.
Universal Power Shovel Co., Detroit.

Shovels, Gasoline
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bay City Dredge Wks., Bay City, Mich.
Bucyrus-Erie Company, Erie, Pa.
General Excavators Co., Marion, O.
Harnischfeger Corporation, Milwaukee.
Industrial Brownhoist Corp., Cleveland.
Insley Mfg. Co., Indianapolis, Ind.
Koehring Company, Milwaukee, Wis.
Link Belt Co. 2045 W. Hunting Park Ave. Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion O.
Ohio Power Shovel Co., Lima, O.
Orton Crane & Shovel Co., Chicago, Ill.
Osgood Co., Marion, O.
Speeder Mchy. Corp. Cedar Rapids Ia.
Thew Shovel Co., Lorain, O.
Trackson Co., 433 Clinton St., Milwaukee Wis.
Universal Crane Co. Lorain, O.
Universal Power Shovel Co., Detroit.

Shovels, Gasoline Crawler
General Excavators Co., Marion, O.
Harnischfeger Corp., Milwaukee, Wis.
Industrial Brownhoist Co., Cleveland.
Speeded Machinery Co., Cedar Rapids, Ia.

Shovels, Hand
Wood Shovel & Tool Co., Piqua, O.

Shovels, Revolving
(See Gasoline Shovels.)

Shovels, Snow
Rightway Corporation, Chicago, Ill.

Shovels, Steam
American Hoist & Derrick Co., 93 South Robert St., St. Paul, Minn.
Bucyrus-Erie Company, Erie, Pa.
Harnischfeger Corporation, Milwaukee.
Industrial Brownhoist Corp., Cleveland.
Keystone Driller Co., Beaver Falls, Pa.
Marion Steam Shovel Co., Marion, O.
Orton Crane & Shovel Co., Chicago.
Osgood Company, Marion, O.
Thew Shovel Co., Lorain, O.

Shovels, Steam Crawler
Industrial Brownhoist Corp., Cleveland.

Signs, Highway
Armco Culvert & Flume Mfrs., Assn., Middletown, O.
Foote Bros. Gear & Mach. Co., Chicago, Ill.

Silicate, Soda
Philadelphia Quartz Co., Philadelphia, Pa.

Siphons
Armco Culvert Mfrs. Assn., Middletown, O.
James B. Clow & Sons, 201-299 N. Talman Ave., Chicago, Ill.

CLASSIFIED INDEX OF PRODUCTS

Skimmer
Bay City Dredge Wks., Bay City, Mich.
Byers Machine Co., Ravenna, O.
Insley Mfg. Co., Indianapolis, Ind.
Keystone Driller Co., Beaver Falls, Pa.

Skips, Stone
Insley Mfg. Co., Indianapolis, Ind.

Skylights
Klauer Mfg. Co., Dubuque, Ia.

Sleeves, Tapping (Valve)
Darling Valve & Mfg. Co., Williamsport, Pa.

Sludge Collector
Link Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Sluice Gates
American Manganese Bronze Co., Philadelphia, Pa.
Clark Company, H. W., Mattoon, Ill.
U. S. Cast Iron Pipe & Fdry. Co., Burlington, N. J.

Smoke Stacks
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.

Smoothers, Asphalt
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Snow Loaders
Barber-Greene Co., Aurora, Ill.
Haiss Mfg. Co., Geo., New York City.

Snow Plows
J. D. Adams Co., Indianapolis, Ind.
Austin Western Road Machy. Co., Chicago, Ill.
Good Roads Machy. Co., Inc., Kennett Square, Pa.
Klauer Mfg. Co., Dubuque, Ia.

Snow Removal Machinery
Barber-Greene Co., Aurora, Ill.

Spaders
Concrete Steel Co., New York, N. Y.
Sullivan Machinery Co., 819 Wrigley Bldg., Chicago, Ill.

Spark Plugs
Robert Bosch Mfg. Co., Long Island City, N. Y.

Spikes, Spirils and Splice Bars
Sweet's Steel Co., Wiliamsport, Pa.

Spirals
Ryerson & Son., Inc., Jos. T., Chicago.

Spoon, Sewers and Basin
Coleman, Allan, Chicago, Ill.

Spreaders
Burch Corp., Crestline, O.
Goroco Mechanical Spreader Co., Philadelphia, Pa.
Universal Road Machy. Co., Kingston, N. Y.

Spreaders, Ballast
Bucyrus-Erie Company, Erie, Pa.

Sprinklers and Sweepers, Street
Austin Western Rd. Machy. Co., Chicago.
Entyre & Co., Inc., E. D., 63 Jefferson St., Oregon, Ill.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Geo. W. Haiss Mfg. Co., Inc., New York, N. Y.
Universal Road Machy. Co., Kingston, N. Y.

Squibs, Electric
E. I. DuPont de Nemours & Co., Wilmington, Del.

Stairs, Steel
Hughes-Keenan Co., Mansfield, O.

Standards, Lamp, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.

Standpipes
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Connery & Company, Philadelphia.
R. D. Cole Mfg. Co., Newman, Ga.
Fairbanks, Morse & Co., Chicago, Ill.
Pittsburgh-Des Moines Steel, Pittsburgh, Pa.

Steam Purifiers
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Steel
Inland Steel Co., 38 S. Dearborn St., Chicago, Ill.
Ryerson & Son, Joseph T., Chicago.

Steel Plate Construction
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
R. D. Cole Mfg. Co., Newnan, Ga.
Connery & Co., Inc., 3996 N. Second St., Philadelphia, Pa.
Inland Steel Co., 38 S. Dearborn St., Chicago, Ill.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.
Pittsburgh-Des Moines Steel, Pittsburgh, Pa.
Williams Co., G. H., Erie, Pa.

Steel Rock Drill
Chicago Pneumatic Tool Co., New York City.
Ingersoll-Rand Co., New York City.
Schramm, Inc., West Chester, Pa.
Sullivan Machy. Co., Chicago.

Steel, Structural
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Hughes-Keenan Co., Mansfield, O.
Inland Steel Co., 38 S. Dearborn St., Chicago, Ill.
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Steel Traffic Treads
Wood Steel Co., Alan, Conshohocken Pa.

Sterilizing Systems
Everson Filter Co., 647 N. Green St., Chicago, Ill.

Sterilizer, Water
Wallace & Tiernan, Newark, N. J.

Stirrups, Continuous Reinforcing Units
Ryerson & Son, Jos. T., Chicago.

Stoneboats
Lee Trailer & Body Co., Plymouth, Ind.

Stoppers, Pipe
Safety Gas Main Stopper Co., 523 Atlantic Ave., Brooklyn, N. Y.

Stoppers, Water Mains, Etc.
Safety Gas Main Stopper Co., New York City.

Stops, Curb, Gooseneck
Mueller Co., Decatur, Ill.

Strand (Guy, Special and Transmission)
John A. Roebling's Sons Co., Trenton, N. J.

Strainers
Fulton Iron Works Co., St. Louis, Mo.

Strainers, Well
Layne & Bowler Co., Memphis, Tenn.
F. Thorpe, 1932 Illinois Ave., East St. Louis, Ill.

Street Flushers
Entyre & Co., Inc., E. D., 63 Jefferson St., Oregon, Ill.

Street Light Standards
Novo Engine Co., 220 Porter St., Lansing, Mich.

Street Sprinklers
Entyre & Co., Inc., E. D., 63 Jefferson St., Oregon, Ill.

Street Sweeping Material
Huntsville Fiber & Veneer Wks., Huntsville, Ala.

Strip, Road
Inland Steel Co., 38 S. Dearborn St., Chicago, Ill.
Jos. T. Ryerson & Son, Inc., Chicago, Ill.

Subgrade Finishing Machines
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Subgrade Markers, Highway
Roughan Paving Gauge Co., Fond du Lac, Wis.

Subgrading Machines
The Hug Co., Highland, Ill.

Supplies, Heating, Steam and Gas.
James B. Clow & Sons, 201-299 N. Talman Ave., Chicago, Ill.

Supplies, Hydraulic
Clark Co., H. W., Mattoon, Ill.

Surfacer, Highway
Concrete Surfacing Machy. Co., Cincinnati, O.
Ingersoll-Rand Co., New York, N. Y.

Surveying Instruments
Buff & Buff Mfg. Co., Boston, Mass.
Warren-Knight Co., Philadelphia, Pa.

Sweepers, Street
Austin Western Rd. Machy. Co., Chicago, Ill.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Universal Road Machinery Co., Kingston, N. Y.

Swimming Pool Filter Systems
Bacharach & Co., E. W., Kansas City, Mo.

Swimming Pools & Equipment
Everson Filter Co., 647 No. Green St., Chicago, Ill.

Switches, Portable
Sweet's Steel Co., Williamsport, Pa.

Tables, Transfer
Industrial Brownhoist Corp., Cleveland.

Tampers, Trench
Chicago Pneumatic Tool Co., New York, N. Y.
Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.
Schramm, Inc., West Chester, Pa.

Tank Car Heaters
Entyre & Co., Inc., E. D., 63 Jefferson St., Oregon, Ill.

Tanks
R. D. Cole Mfg. Co., Newnan, Ga.
Jos. Honhorst Co., Cincinnati, O.
Pacific Flush-Tank Co., 4241 Ravenswood Ave., Chicago, Ill. Also 9 Park Place, New York, N. Y.

Tanks, Air Compressor
Chicago Pneumatic Tool Co., New York.
R. D. Cole Mfg. Co., Newman, Ga.

Tanks, Elevated Steel, Water
R. D. Cole Mfg. Co., Newnan, Ga.
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Tanks, Oil Storage
Mohawk Asphalt Heater Co., Schenectady, N. Y.

Tanks, Sand Settling
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Tanks, Septic
Mohawk Asphalt Heater Co., Schenectady, N. Y.

Tanks, Sprinkling
Entyre & Co., Inc., E. D., 63 Jefferson St., Oregon, Ill.

Tanks, Steel
Clark Co., H. W., Mattoon, Ill.
R. D. Cole Mfg. Co., Newnan, Ga.
Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

Tapping Machines
Mueller Co., Decatur, Ill

Tar Heaters, Kettles
Hauck Mfg. Co., Brooklyn, N. Y.
Honhorst Co., Jos., Cincinnati.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Tar, Road
American Tar Products Corp., Pittsburgh, Pa.
Barrett Co., New York, N. Y.

Tarvia
Barrett Co., New York, N. Y.

Tar and Pitch, Paving
(See Road Tar.)

Tees, Threadless
Geo. H. Snell, Attleboro, Mass.

Teeth, Dipper and Bucket
Western Crucible Steel Casting Co., Minneapolis, Minn.

Teeth, Scarifier
Western Crucible Steel Casting Co., Minneapolis, Minn.

Telephones (Bell System)
Amer. Tel. & Teleg. Co., New York.

Templates, Subgrade
Hug Co., Highland, Ill.

Templets, Highway Strike Off
Roughan Paving Gauge Co., Fond du Lac, Wis.

Testers, Water Meter
Clark Co., H. W., Mattoon, Ill.

Tests, Road Material
Hug Co., Highland, Ill.

Testing Laboratories
(See Engineers' Directory.)

Thawing Equipment
Aeroil Burner Co., West New York, N. J.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Ties, Steel
Sweet's Steel Co., Williamsport, Pa.

Tile, Drain
Clay Products Assn., Chicago, Ill.
Wm. Dee Clay Mfg. Co., Chicago, Ill.

Tires, Rubber
Goodrich Rubber Co., B. F., Akron, O.
Hood Rubber Co., Watertown, Mass.

Tools, Asphalt Paving
Littleford Bros. 454 E. Pearl St., Cincinnati, O.

Tool Boxes, Portable
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Tools, Caulking
Clark Co., H. W., Mattoon, Ill.
Leadite Co., Philadelphia, Pa.
Mueller Co., Decatur, Ill.
Schramm, Inc., West Chester, Pa.

Tools, Electric
Chicago Pneumatic Tool Co., New York.

Tools, Hand, Blacksmith
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Tools, Hydraulic
Clark Co., H. W., Mattoon, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Tools, Mechanic
Ryerson & Son, Inc., Jos. T., Chicago.

Tools, Pipe Jointing
Leadite Co., Philadelphia, Pa.

Tools, Pneumatic
Chicago Pneumatic Tool Co., New York.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Torch, Gasoline Blow
Hauck Mfg. Co., Brooklyn, N. Y.
G. H. Williams Co., Erie, Pa.

Torches, Bomb Shell
McCloskey Torch Co., Toledo, O.

Torches, Road
McCloskey Torch Co., Toledo, O.
National Carbon Co., New York, N. Y.
Toledo Pressed Steel Co., Toledo, O.

Torches, Thawing, Oil and Kerosene
Aeron Burner Co., Inc., Union Hill, N. J.
Hauck Mfg. Co., Brooklyn, N. Y.
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Towers, Concrete
(See Hoists, Conc. Tower.)

Towers, Radio
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Towers, Transmission
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Track, Industrial and Portable
Ryerson & Son, Inc., Jos. T., Chicago.
Sweet's Steel Co., Williamsport, Pa.

Traction, Crawling Type
Trackson Co., Milwaukee.

Tractors
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Atlas Engr. Co., Clintonville, Wis.
Caterpilar Tractor Co., San Leandro, Cal.
Cleveland Tractor Co., 10320 Euclid Ave., Cleveland, O.
Electric Wheel Co., Quincy, Ill.
Foote Bros. Gear & Mach. Co., Chicago, Ill.
French & Hecht Co., Davenport, Ia.
Haiss Mfg. Co., Inc., Geo., New York.
International Harvester Co., Chicago.
Monarch Tractor Corp., Springfield, Ill.

Tractors, Crawler, Traction and Caterpillar
(See Tractors.)

Tractors, Industrial
International Harvester Co. of America, Chicago, Ill.

Tractors, Road
Trackson Co., 533 Clinton St., Milwaukee, Wis.

Tractors, Road Gasoline
(See Tractors.)

Tractors, Truck
International Harvester Co. of America, Chicago, Ill.

Tractors, Wheel
International Harvester Co. of America, Chicago, Ill.

Tractor Scraper
Roderick Lean Co., Mansfield, O.

Trailers, All Kinds
Electric Wheel Co., Quincy, Ill.
French & Hecht, Davenport, Ia.
Freuhauf Trailer Company, 10937 Harper Ave., Detroit, Mich.
Highway Trailer Co., Edgerton, Wis.
Lee Trailer & Body Co., Plymouth, Ind.
Martin Trailer Co., Westfield, Mass.
Rogers Bros. Corp., Albion, Pa.

Traffic Marker
Littleford Bros., 454 E. Pearl St., Cincinnati, O.

Traffic Signals
Wallace & Tiernan, Inc., Newark, N. J.

Traffic Treads, Steel
Wood Steel Co., Alan, Conshohocken, Pa.

Tramways, Overhead
Harnischfeger Corp., Milwaukee, Wis.

Transits and Levels
Buff & Buff Mfg. Co., Boston, Mass.
Kern & Co., New York, N. Y.
Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa.

Transmission and Machinery Power
Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.

Treads, Safety
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Concrete Steel Co., New York, N. Y.
Ryerson & Son., Inc., Jos. T., Chicago.

Treads, Traffic Steel (Bridges)
American Pressed Steel Co., Philadelphia, Pa.
Central Iron & Steel Co., Harrisburg, Pa.
Wood Steel Co., Alan, Conshohocken, Pa.

Trenchers
Bay City Dredge Wks., Bay City, Mich.
Buckeye Traction Ditcher Co., Findlay, Ohio.
Harnischfeger Corp., Milwaukee, Wis.

Trench Braces
(See Braces, Trench.)

Trench Machines
Buckeye Traction Ditcher Co., Findlay, Ohio.

CLASSIFIED INDEX OF PRODUCTS

Trolleys, I-Beams
Harnischfeger Corp., Milwaukee, Wis.

Trucks, Dump
Graham Brothers, Detroit, Mich.
Hug Co., Highland, Ill.
International Harvester Co. of America, Chicago, Ill.

Trucks
Chevrolet Motor Company, Detroit, Mich.
General Motors (Chevrolet), Detroit.
Graham Bros., Detroit, Mich.
Hug Co., Highland, Ill.
International Harvester Co. of America, Chicago, Ill.

Trucks, Machinery
Electric Wheel Co., Quincy, Ill.
Lee Trailer & Body Co., Plymouth, Ill.

Trucks, Portable Machinery
(See Trucks, Machinery.)

Trusses, Steel, Roof
Concrete Steel Co., New York, N. Y.

Tubular Steel Scaffolding
Patent Scaffolding Co., New York, N. Y.

Tunnel Liner Plates
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Turbine Gears
DeLaval Steam Turbine Co., Trenton, N. J.

Turbines, Hydraulic Impulse and Reaction
Allis-Chalmers Mfg. Co., Milwaukee.

Turbines, Steam
Allis-Chamers Mfg. Co., Milwaukee.
DeLaval Steam Turbine Co., Trenton, N. J.

Turnbuckles
Coleman, Allan, Chicago, Ill.
Maggart Corp., Chicago, Ill.
Wiliamsport Wire Rope Co., Williamsport, Pa.

Turnouts
Sweet's Steel Co., Williamsport, Pa.

Turntables
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.
Hug Co., Highland, Ill.
Western Structural Co., Moline, Ill.

Unloaders, Ballast
Lidgerwood Mfg. Co., Elizabeth, N. J.
Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Marion Steam Shovel Co., Marion, O.

Unloaders, Car and Wagon
Atlas Engineering Co., Clintonville, Wis.
Galion Iron Works Mfg. Co., Galion, O.
Good Roads Machinery Co., Inc., Kennett Square, Pa.
Haiss Mfg. Co., Geo., New York, N. Y.
Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Industrial Brownhoist Co., Cleveland, Ohio.
Universal Road Machinery Co., Kingston, N. Y.

Unloaders, Coal and Stone
(See Unloaders, Car and Wagon.)

Unloading Plants
Atlas Engineering Co., Clintonville, Wis.
Bucyrus-Erie Co., Erie, Pa.

Valve Boxes
Bourbon Copper & Brass Works Co., 618-620 E. Front St., Cincinnati, O.
Reading Meter Repair Co., Reading, Pa.
Central Foundry Co., New York, N. Y.
Clark Co., H. W., Mattoon, Ill.
Columbia Iron Works, Chattanooga, Tenn.
Klauer Mfg. Co., Dubuque, Ia.
Mueller Co., Decatur, Ill.
S. E. T. Valve & Hydrant Co., New York, N. Y.
R. D. Wood & Co., Philadelphia, Pa.

Valve Check
Columbia Iron Works, Chattanooga, Tenn.

Valve Operating Parts
American Manganese Bronze Co., Philadelphia, Pa.

Valves
American Manganese Bronze Co., Philadelphia, Pa.
James B. Clow & Sons, 201-299 N. Talman Ave., Chicago, Ill.
Crane Co., Chicago, Ill.
Darling Valve & Mfg. Co., Williamsport, Pa.
S. E. T. Valve & Hydrant Co., New York, N. Y.
R. D. Wood & Co., Philadelphia, Pa.

Valves, Air, Water, Steam and Gas
Automatic Cone Valve Co., Chicago, Ill.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Valves, Altitude
Automatic Cone Valve Co., Chicago, Ill.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.

Valves, Air-Vacuum
Automatic Cone Valve Co., Chicago, Ill.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Valves, Angle, Check, Gate and Globe
Automatic Cone Valve Co., Chicago, Ill.
Bourbon Copper & Brass Works Co., 618-620 E. Front St., Cincinnati, O.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
Mueller Co., Decatur, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Valves, Automatic
Automatic Cone Valve Co., Chicago, Ill.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Valves, Chlorine Cylinder
Wallace & Tiernan, Newark, N. J.

Valves, Fire Service
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
Mueller Co., Decatur, Ill.
R. D. Wood & Co., Philadelphia, Pa.

Valves, Float
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
Mueller Co., Decatur, Ill.

Valves, Foot
Mueller Co., Decatur, Ill.

Valves, Gate
Columbian Iron Works, Chattanooga, Tenn.
Darling Valve & Mfg. Co., Williamsport, Pa.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Valves, Flush
Mueller Co., Decatur, Ill.

Valves, Hydraulic
R. D. Wood & Co., Philadelphia, Pa.

Valves, Pipe
(See Valves, Angle Check Gate and Globe.)

Valves, Regulating
Automatic Cone Valve Co., Chicago, Ill.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
Simplex Valve & Meter Co., 6749 Upland St., Philadelphia, Pa.

Valves, Water Relief
(See Valves, Angle, Check, Gate and Globe.)

Valves, Return
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.

Valves, Safety
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.

Valves, Water Works
Automatic Cone Valve Co., Chicago, Ill.
Columbian Iron Works, Chattanooga, Tenn.
Darling Valve & Mfg. Co., Williamsport, Pa.
Golden-Anderson Valve Specialty Co., 1385 Fulton Bldg., Pittsburgh, Pa.
R. D. Wood & Co., Philadelphia, Pa.

Vats, Cast Iron
Fulton Iron Works Co., St. Louis, Mo.

Ventilator, Shop, Roundhouses
Klauer Mfg. Co., Dubuque, Ia.

Wagons, Asphalt
J. D. Adams Co., Indianapolis, Ind.

Wagons, Dump
J. D. Adams Co., Indianapolis, Ind.
Austin Western Rd. Mchy. Co., Chicago, Ill.
The Baker Manufacturing Co., 506 Stanford Ave., Springfield, Ill.
Western Wheeled Scraper Co., Aurora, Ill.

Wagons, Dump, Auto
Austin Western Rd. Mchy. Co., Chicago, Ill.

Wagons, Dump, Horse Drawn
J. D. Adams Co., Indianapolis, Ind.
Western Wheeled Scraper Co., Aurora, Ill.

Wagons, Grader
Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa.

Wall Coping
Clay Products Assn., Chicago, Ill.

Washers
Smith Engineering Works, 82 Capitol Drive, Milwaukee, Wis.

Washers, Rawhide Meter
Mabbs Hydraulic Packing Co., Chicago, Ill.

Washing Plants, Sand and Gravel
Allis-Chalmers Mfg. Co., Milwaukee.
Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa.; 300 W. Pershing Rd., Chicago, Ill.
Universal Road Machinery Co., Kingston, N. Y.

Water Coolers
Everson Filter Co., 647 N. Green St., Chicago, Ill.

Water Leak, Locating Instruments
Clark Co., H. W., Mattoon, Ill.
Reading Meter Repair Co., Reading, Pa.

Water, Level Recorders
Clark Co., H. W., Mattoon, Ill.

Water-Main Cleaning
National Water Main Cleaning Co., New York, N. Y.

Water Main Sterilizer
Wallace & Tiernan, Newark, N. J.

Waterproofing Oil Asphalt
American Asphalt Grouting Co., Chattanooga, Tenn.
Standard Oil Co. of Ind., Chicago, Ill.
Standard Oil Co. of N. Y., New York.
Texas Co., New York, N. Y.

Waterproofing Compounds and Materials
Barrett Co., New York, N. Y.
Philip Carey Co., Cincinnati, O.
Ceresit Waterproofing Corp., Chicago.
Servicised Products Corp., Chicago, Ill.

Water, Purification
Bacharach & Co., E. W., Kansas City, Mo.
Everson Filter Co., 647 No. Green St., Chicago, Ill.
Paradon Engineering Co., Arlington, N. J.
Wallace & Tiernan, Inc., Newark, N. J.

Water Softeners
Crane Co., Chicago, Ill.
Everson Filter Co., 647 N. Green St., Chicago, Ill.
Zeolite Chemical Co., 140 Cedar St., New York, N. Y.

Water Works Supplies
Clark Co., H. W., Mattoon, Ill.
Mueller Co., Decatur, Ill.

Weed Burners
Hauck Mfg. Co., Brooklyn, N. Y.

Welded Fabric
Wickwire Spencer Co., New York, N. Y.

Welders, Electric
American Hoist & Derrick Co., 93 S. Robert St., St. Paul, Minn.
Klauer Mfg. Co., Dubuque, Ia.

Welding, Wire
John A. Roebling's Sons Co., Trenton, N. J.

Well Casings, Concrete
F. Thorpe, 1932 Illinois Ave., East St. Louis, Ill.

Well Drilling Machinery
American Well Works, Aurora, Ill.
Austin Mfg. Co., Chicago, Ill.
Ingersoll-Rand Co., New York, N. Y.
Keystone Driller Co., Beaver Falls, Pa.
Layne & Bowler Co., Memphis, Tenn.
F. Thorpe, 1932 Illinois Ave., East St. Louis, Ill.

Well Equipment
American Well Works, Aurora, Ill.

Wells, "Air Made"
Sullivan Machy. Co., 819 Wrigley Bldg., Chicago, Ill.

Wells
Layne & Bowler Co., Memphis, Tenn.
F. Thorpe, 1932 Illinois Ave., East St. Louis, Ill.

Wells, Concrete
F. Thorpe, 1932 Illinois Ave., East St. Louis, Ill.

Wheels, Metal
Electric Wheel Co., Quincy, Ill.
French & Hecht, Davenport, La.

Wheels, Rubber Tired
(See Wheels, Metal.)

Wheels, Steel
French & Hecht, Davenport, La.

Winches
American Hoist & Derrick Co., 93 S. Robert St., St. Paul, Minn.
Chicago Pneumatic Tool Co., New York, N. Y.
Haiss Mfg. Co., Inc., Geo., New York.
Lidgerwood Mfg. Co., Elizabeth, N. J.

Winches, Motor Truck
Bay City Foundry & Machine Co., Bay City, Mich.
Chevrolet Motor Company, Detroit, Mich.

Winches, Ship, Hand, Steam and Electric
Lidgerwood Mfg. Co., Elizabeth, N. J.

Windlasses
American Hoist & Derrick Co., 93 S. Robert St., St. Paul, Minn.

Window Sash Steel
Ryerson & Son., Inc., Jos. T., Chicago.

Windows, Steel
Ryerson & Son, Inc., Jos. T., Chicago.

Wires and Cables (All Purposes)
American Steel & Wire Co., Chicago.
John A. Roebling's Sons Co., Trenton, N. J.

Wire Brushes, Pneumatic
Chicago Pneumatic Tool Co., 6 E. 44th St., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.

Wire, Electrical and Cable
John A. Roebling's Sons Co., Trenton, N. J.

Wire Fence
American Steel & Wire Co., Chicago.
American Wire Fence Co., Chicago.
Page Steel & Wire Co., Bridgeport, Conn.

Wire, Leading and Connecting
E. I. DuPont de Nemours & Co., Inc., Wilmington, Del.

Wire, Mesh Reinforcing
American Steel & Wire Co., Chicago.
Wickwire Spencer Steel Co., New York, N. Y.

Wire Rope
(See Rope, Wire.)

Wire Rope Fittings
(See Rope, Wire, Fittings.)

Wire Rope Slings
John A. Roebling's Sons Co., Trenton, N. J.

Wire, Steel
American Steel & Wire Co., Chicago, Ill.

Wood Boring Machines, Pneumatic
Chicago Pneumatic Tool Co., New York, N. Y.
Ingersoll-Rand Co., New York, N. Y.
Schramm, Inc., West Chester, Pa.

Wood Preservative
Philip Carey Co., Cincinnati, O.

Wrenches
Trimont Mfg. Co., Boston, Mass.

Wrenches, Strap
Coleman, Allen, Chicago, Ill.

Yokes, Coupling
Clark Co., H. W., Mattoon, Ill.

GEOGRAPHICAL INDEX OF DEALERS AND DISTRIBUTORS

Note: Each equipment distributor's name is followed by the name of the firms whose products he handles.
The alphabetical index of firms will be found on page 5.
See also lists on individual pages.

ALABAMA

Birmingham

Chas. T. Lehman
2300 Avenue A.
Schramm, Inc.
U. S. Cast Iron Pipe & Fdy. Co.
First Ave. and 20th St.
Wimberly & Thomas Hdw.
McCloskey Torch Company

Mobile

Lawrence-Goodling Co., Inc.
161-165 N. Water St.
Schramm, Inc.

ARIZONA

Phoenix

Arizona Road Machinery Company
Schramm, Inc.
James C. Bain
211 Security Bldg.
Economy Pumping Mach. Co.
Vernon L. Clark Bldg. Mat. Co.
341 N. 1st St.
McCloskey Torch Company
Neil B. McGinnis
15 E. Jackson St.
McCloskey Torch Company

Tucson

Machinery Engineering Co.
246 E. Broadway
Schramm, Inc.

Yuma

J. D. Lines
1120 5th Ave.
Peerless Pump Co.

ARKANSAS

Ft. Smith

Speer Hardware Co.
McCloskey Torch Company

Little Rock

Kern-Limerick, Inc.
2800 W. 15th St.
Schramm, Inc.
Joe Lyons Machinery Co.
112 N. Louisiana St.
McCloskey Torch Company
C. O. Miller Co.
Home Insurance Bldg.
Yeomans Bros.

CALIFORNIA

Bakersfield

Peerless Pump Company
1514 20th St.

Fresno

Peerless Pump Company
1225 Broadway St.

Lancaster

Siebenthal Bros.
Peerless Pump Company

Los Angeles

Construction Machinery Co.
455 E. Third St.
Schramm, Inc.
F. C. Millard Enginering Co.
1855 Industrial St.
Yeomans Bros. Co.
Republic Flow Meters Co.
U. S. Cast Iron Pipe & Fdy. Co.
403 S. Hill St.
Wallace & Tiernan Co., Inc.
G. T. Luippold, 3923 W. 6th St.
Water Works Supply Co.
Wright & Callender Bldg.
Automatic Cone Valve Co.
Golden Anderson Valve Spec. Co.
Simplex Valve & Meter Co.
R. D. Wood & Co.
Jones-Lyman & Co., Inc., Bartlett Bldg., 215 W. 7th St.

Oakland

Spears-Wells Machinery Co.
Schramm, Inc.

Sacramento

Peerless Pump Company
1327 O St.

San Francisco

C. H. Cobb
55 New Montgomery St.
Yeomans Bros. Co.
Industrial & Municipal Supply Co., Inc.
Room 314, 7 Front St.
Peerless Pump Company
Jenison Machinery Co.
[illegible] Fremont St.
McCloskey Torch Company
Republic Flow Meters Co.
J. Harry Russell
Monadnock Bldg.
Economy Pumping Machy. Co.
U. S. Cast Iron Pipe & Fdry. Co.
3rd and Market Sts.
Wallace & Tiernan Co., Inc.
Alex. Bell, 7 Front St.
Water Works Supply Co.
Sharon Bldg.
Automatic Cone Valve Co.
Golden Anderson Valve Spec. Co.
Simplex Valve & Meter Co.
R. D. Wood & Co.
Jones-Lyman & Co., Inc., Russ Bldg., 235 Montgomery St.

San Jose

Peerless Pump Company
635 S First St.

Tulare

Figgins & Curtis
South K and Owens Sts.
Peerless Pump Company

COLORADO

Denver

Daly Co.
1635 Blake St.
Yeomans Bros. Co.
Denver Fire Clay Company
Simplex Valve & Meter Co.
H. W. Moore Equipment Co.
Sixth and Acoma Sts.
Schramm, Inc.
Republic Flow Meters Co.
Wallace & Tiernan Co., Inc.
C. R. Cederberg, 5531 E. 14th St.

CONNECTICUT

East Hartford

Holmes Talcott Co.
McCloskey Torch Company

Hartford

K. B. Noble Co.
249-251 Pearl St.
McCloskey Torch Company

New Haven

W. I. Clark Co.
217 Lafayette St.
McCloskey Torch Company
Gesner Contractors Equipment Co.
254 Park St.
Schramm, Inc.

DELAWARE

Wilmington

Delaware Hdw. Co.
McCloskey Torch Company

DISTRICT OF COLUMBIA

Washington

Hudson Supply & Equipment Co.
7th and T Sts.
McCloskey Torch Company
Stewart Motor Co.
346 W. Penn. Ave., N. W.
Schramm, Inc.

FLORIDA

Ft. Lauderdale

J. A. Whelan
Box 764
Wemlinger, Inc.

Jacksonville

The Cameron & Barkley Co.
605 E. Forsyth St.
Schramm, Inc.
R. H. Johnson
660 College St.
Economy Pumping Machy. Co.
McDonald & Burgman
McCloskey Torch Company
Wallace & Tiernan Co., Inc.
C. H. Eastwood, 408 Hilderbrandt Bldg.

Lake Worth

R. D. Wood & Co.
R. D. Wertz, 113 S. N St.

Miami

Cont. Equipment Co.
2315 N. Miami Ave.
McCloskey Torch Company
Llewellyn Machinery Corp.
1031 N. Miami Ave.
Schramm, Inc.
Railey Milam Hdw. Co.
27 W. Flagler St.
McCloskey Torch Company

Tampa

J. L. Hart Machinery Company
Schramm, Inc.
E. F. Leger
309 Franklin St.
Yeomans Bros. Co.
A. R. Merrill
1202 First National Bank Bldg.
George H. Snell Co.
Ogden Machinery Co.
17th and First Ave.
Wemlinger, Inc.

GEORGIA

Atlanta

R. S. Armstrong & Bros., Inc.
676 Marietta St., N. W.
Wemlinger, Inc.
Burford, Hall & Smith
Red Rock Bldg.
Yeomans Bros.
Wm. J. Neville
Candler Bldg.
Simplex Valve & Meter Co.
Neville & Cleary, Inc.
Candler Bldg.
Automatic Cone Valve Co.
Golden Anderson Valve Spec. Co.
Republic Flow Meters Co.
Tractor & Machinery Co.
351 Whitehall St.
Schramm, Inc.

Columbus

Columbus Iron Works
McCloskey Torch Company

IDAHO

Boise

Howard-Cooper Corp.
Box 1305
Schramm, Inc.

ILLINOIS

Chicago

A. F. Barron
30 N. Michigan Blvd.
Simplex Valve & Meter Co.
G. C. Harnish
Room 532, 9 S. Clinton St.
Peerless Pump Company
Himelblau & Agazim Co.
30 N. Dearborn St.
Automatic Cone Valve Co.
Arthur S. Hindman
1221 First National Bank Bldg.
Columbia Silica Company
O. C. Keckley Co.
565 Washington Blvd.
Golden Anderson Valve Spec. Co.
Republic Flow Meters Co.
Schramm, Inc.
549 W. Washington St.
U. S. Cast Iron Pipe & Foundry Co.
122 S. Michigan Blvd.
Wallace & Tiernan Co., Inc.
180 N. Wacker Drive
Wemlinger, Inc.
228 N. La Salle St.
R. D. Wood & Co.
T. A. Storms, 7243 Jeffrey Ave.

Maywood

Everhot Mfg. Co.
McCloskey Torch Company

Peoria

H. F. Kircher & Co.
Lehman Bldg.
Yeomans Bros. Co.

Rockford

J. P. Adolph
1405 Camp Ave.
Economy Pumping Machy. Co.

INDIANA

Alexandria

Beatson Supply Co.
McCloskey Torch Company

Gary

Republic Flow Meters Co.

Indianapolis

Acme Engineering Agency
Term. Trac. Bldg.
Golden-Anderson Valve Spec. Co.
Barnett-Dunning, Inc.
143 East Ohio St.
Wemlinger, Inc.
Bock Equipment Co.
1900 Northwestern Ave.
Schramm, Inc.
S. E. Fenstermaker & Co.
821 Hume-Mansur Bldg.
Yeomans Bros. Co.
J. A. Graves
923 N. Denny St.
Peerless Pump Company
Hoover Bros. Co.
601 State Life Bldg.
Economy Pumping Machinery Co.
Wallace & Tiernan Co., Inc.
W. A. Hockett, 1004 Fletcher Trust Bldg.

South Bend

Smith-Monroe Co.
1912 S. Main St.
Yeomans Bros. Co.
South Bend Supply Co.
McCloskey Torch Company

Wabash

Roy Wertenberger
308 Eagles Bldg.
George H. Snell Company

IOWA

Davenport

Gierke Robinson Co.
McCloskey Torch Company
D. C. Murphy Co., Inc.
Security Bldg.
Yeomans Bros. Co.

Des Moines

Globe Machinery & Supply Co.
207 W. Court Ave.
McCloskey Torch Company
Peerless Pump Company
C. L. Knehr
521 Hubbell Bldg.
Yeomans Bros. Co.
Stiles-Murray, Inc.
213 Securities Bldg.
Schramm, Inc.
Wickes Eng. & Const. Co.
1441 Bluff St.
Wemlinger, Inc.

Dubuque

F. M. Jaeger Hdw. Co.
768 Main St.
McCloskey Torch Company

Marshalltown

Iowa Municipal Supply Co.
McCloskey Torch Company

Mason City

Mason City Builders Supply Co.
McCloskey Torch Company

Sioux City

The Orcutt Co.
Orcutt Bldg.
McCloskey Torch Company

KANSAS

Kansas City

Industrial Machinery Co.
McCloskey Torch Company

Leavenworth

Reyburn Hardware
S. E. Cor. 5th and Cherokee Sts.
McCloskey Torch Company

Salina

Lee Hardware Co.
McCloskey Torch Company
Salina Supply Co.
McCloskey Torch Company

Topeka

Bowen-Nuss-Brown Hdw.
511-13 Kansas St.
McCloskey Torch Company
Topeka Road & Metal Co.
Schramm, Inc.

Wichita

E. N. Kirwan
220 W. Lewis St.
Schramm, Inc.

KENTUCKY

Lexington

W. C. Sidener
375 Park Ave.
Schramm, Inc.

GEOGRAPHICAL INDEX OF DEALERS AND DISTRIBUTORS

Wallace & Tiernan Co., Inc.
H. N. Jernigan, 424 Kentucky Ave.
B. B. Wilson Co.
139 N. Mill St.
McCloskey Torch Company

Louisville

Dehler Bros.
McCloskey Torch Company
S. E. Fenstermaker & Co.
901 Realty Bldg.
Yeomans Bros.
Lawler Machinery Co.
Starks Bldg.
Schramm, Inc.
Mechanical Equipment Co.
305 Louisville Trust Bldg.
Economy Pumping Machinery Co.
J. F. Shouse & Co.
Starks Bldg.
Automatic Cone Valve Co.

Paducah

Paducah Iron Works
McCloskey Torch Company
H. A. Peter Supply Co.
Schramm, Inc.

LOUISIANA

Monroe

Monroe Hardware Co.
McCloskey Torch Company

New Orleans

E. W. Carr, Inc.
901 Carondelet St.
Economy Pumping Machy. Co.
Walter Castanedo, Inc.
1105 Maritime Bldg.
Yeomans Bros. Co.
Neville & Cleary, Inc.
Union Indemnity Bldg.
Automatic Cone Valve Co.
Golden-Anderson Valve Spec. Co.
Ole K. Olson Co.
Box 68, Station G
Schramm, Inc.
C. T. Patterson Co., Inc.
801 Tchoupitoulas.
McCloskey Torch Company
W. D. Taulman
Union Indemnity Bldg.
Simplex Valve & Meter Co.

MAINE

Camden

J. C. Curtis, Inc.
McCloskey Torch Company

Portland

W. L. Blake Co.
George H. Snell Co.
Ever New Supply Co.
McCloskey Torch Company
Maine Road Equipment Co.
315 Forest Ave.
McCloskey Torch Company
Schramm, Inc.

MARYLAND

Baltimore

Clark & Freeland, Inc.
1503 Hearst Tower Bldg.
Wemlinger, Inc.
W. I. Collier
522 Park Ave.
Economy Pumping Machy. Co.
Morton McI. Dukehart & Co.
Whitaker Bldg.
Yeomans Bros.
John C. Louis Co.
221 S. Eutaw St.
McCloskey Torch Company
John F. Murray
321 Equitable Bldg.
Peerless Pump Company
Wallace & Tiernan Co.
H. F. Cordes, 4807 Norwood Ave.

Hagerstown

Hagerstown Equipment Co.
McCloskey Torch Company

MASSACHUSETTS

Boston

Ames & Campbell
261 Franklin St.
Automatic Cone Valve Co.
The Bond Company
84 High St.
McCloskey Torch Company
Braman Dow & Co.
George H. Snell Co.
Central Equipment Co.
31 State St.
Wemlinger, Inc.
Chas. J. McCarty & Co.
48-50 Pearl St.
McCloskey Torch Company
N. L. C. Engr. & Equip. Co.
101 Tremont St.
Golden Anderson Valve Spec. Co.
New England Implement Co.
19 Jersey St.
Schramm, Inc.
Pierce-Perry Co.
George H. Snell Company
Power Equipment Co.
250 Stuart St.
Yeomans Bros. Co.
Republic Flow Meters Co.
Geo. W. Stetson
141 Milk St.
Simplex Valve & Meter Co.
Sumner & Dunbar
12 Pittsburgh St.
George H. Snell Co.
Waldo Bros. Co.
202 Southampton St.
Sullivan Machinery Co.
Wallace & Tiernan Co.
C. G. Hart, 932 Park Square Bldg.

Cambridge

Dyar Sales & Machinery Co.
McCloskey Torch Company

Fall River

Borden & Remington
McCloskey Torch Company

Lowell

C. B. Coburn Co.
McCloskey Torch Company

Springfield

Holmes & Talcott Co.
McCloskey Torch Company

Worcester

R. D. Wood & Co.
R. M. Simon, 25 Berkmans St.

MICHIGAN

Detroit

American Pump & Supply Co.
General Motors Bldg.
Golden Anderson Valve Spec. Co.
Simplex Valve & Meter Co.
H. J. Clemens
517 E. Larned St.
Economy Pumping Machinery Co.
Contractors Equipment Co.
5163 Martin Ave.
McCloskey Torch Company
Coon DeVisser Co.
2051 W. Lafayette St.
Sullivan Machinery Company
James E. Degan Co.
622 1st St.
Automatic Cone Valve Co.
Earle Equipment Co.
6331 Tireman Ave.
McCloskey Torch Company
Schramm, Inc.
R. G. Moeller Co.
8900 Livernois Ave.
Wemlinger, Inc.
Poe Company
414-420 Curtis Bldg., 2842 W. Grand Blvd.
Peerless Pump Company
Power Plant Supply Co.
739 Fisher Bldg.
Yeomans Bros. Co.
Republic Flow Meters Co.
Wallace & Tiernan Co., Inc.
W. E. Smith
714 Dime Bank Bldg.

Grand Rapids

Barclay, Ayers & Bertsch Co.
321 Bond Ave., N. W.
McCloskey Torch Company
R. E. DeKraker
G. R. National Bank Bldg.
Yeomans Bros. Co.
Kellogg-Burlingame Co.
McCloskey Torch Company
F. D. Lake Co.
16 Campau Ave., N. W.
Schramm, Inc.
F. A. Simonds & Son
301 Peninsula Bldg.
Economy Pumping Machinery Co.

Jackson

Smith-Winchester Co.
McCloskey Torch Company

Kalamazoo

Bond Supply Co.
McCloskey Torch Company

Marshall

Grace Const. & Supply Co.
S. Kalamazoo Ave.
McCloskey Torch Company

MINNESOTA

Crosby

The Crosby Hdw. Co.
McCloskey Torch Company

Duluth

Wm. Constable Company
Providence Bldg.
Peerless Pump Company
Marshall Wells Co.
McCloskey Torch Company
Peter Meagher
329-331 W. Michigan St.
Schramm, Inc.

Minneapolis

Kent Engr. Co.
Builders Exchange Bldg.
Golden-Anderson Valve Specialty Co.
Simplex Valve & Meter Co.
Republic Flow Meters Co.
T. W. Rosholt Co.
McCloskey Torch Company
U. S. Cast Iron Pipe & Foundry Co.
6th and Hennepin Ave.
Wallace & Tiernan Co., Inc.
240 S. Fourth St.

St. Paul

Healy-Ruff Co.
765 Hampden Ave.
Yeomans Bros. Co.
F. T. Hildred & Co.
108 East 3rd St.
Sullivan Machinery Company
O'Connell Supply Co.
356 Cedar St.
Economy Pumping Machinery Co.
Raymer Hdw. Co.
56 East 5th St.
McCloskey Torch Company
A. R. Robertson Co.
1603 University Ave.
Peerless Pump Company

MISSISSIPPI

Jackson

Clifford Waterhouse
McCloskey Torch Company

Yazoo

Yazoo Hardware Co.
McCloskey Torch Company

MISSOURI

Joplin

E. A. Martin Machinery Co.
523 School St.
Schramm, Inc.

Kansas City

Air Made Well Co.
Railway Exchange Bldg.
Sullivan Machinery Company
F. W. Bacharach & Co.
Rialto Bldg.
Automatic Cone Valve Co.
C. H. Carr Company
411 Mutual Bldg.
Peerless Pump Company
Forslund Pump & Machinery Co.
3031 Main St.
Yeomans Bros. Co.
Republic Flow Meters Co.
O. G. Smith
110 E. 40th St.
Simplex Valve & Meter Co.
Steam Plant Equip. Co.
Mutual Bldg.
Golden Anderson Valve Specialty Co.
U. S. Cast Iron Pipe & Foundry Co.
13th and Locust Sts.
Wallace & Tiernan Co., Inc.
223 E. 9th St.

St. Joseph

Bristol Supply Co.
402 Messanie
McCloskey Torch Company

St. Louis

Economy Machy & Equip. Co.
321 S. Grand Blvd.
Economy Pumping Machinery Co.
Fickeissen-Finney Equip. Co.
3620 Laclede Ave.
Schramm, Inc.
Foster Mechanical Equipment Co.
923 Chemical Bldg.
Peerless Pump Company
P. A. Haradon
600 Fullerton Bldg.
Golden Anderson Valve Specialty Co.
Arthur T. Hunter
Railway Exchange Bldg.
Automatic Cone Valve Co.
Lincoln Equipment & Materials Co.
1500 N. Broadway
McCloskey Torch Company
B. H. Mueller
1223 Syndicate Trust Bldg.
Yeomans Bros. Co.
Republic Flow Meters Co.
F. W. Taylor
Paul Brown Bldg.
Wemlinger, Inc.
Wallace & Tiernan Co., Inc.
G. I. Nelson
605 Star Bldg.

Springfield

McGregor Hardware Co.
McCloskey Torch Company

MONTANA

Billings

Midland Implement Co.
McCloskey Torch Company

Butte

Hall-Perry Machinery Co.
802 East Iron St.
Schramm, Inc.

NEBRASKA

Lincoln

Nebraska Mat. Co.
McCloskey Torch Company

Omaha

American Machinery & Supply Co.
1113 Howard St.
McCloskey Torch Company
Fuchs Equipment Co.
1003 Farnum St.
McCloskey Torch Company
Schramm, Inc.
D. E. McCulley Co.
1820 St. Marys Ave.
Yeomans Bros. Co.
North Side Hardware Co.
4112 North 24th St.
McCloskey Torch Company

NEW HAMPSHIRE

Farmington

H. J. Canney
McCloskey Torch Company

Nashua

Johnson-Barker Co.
George H. Snell Company

Summersworth

Brackett & Shaw Co.
Schramm, Inc.

NEW JERSEY

Atlantic City

Atlantic Machinery Supply Co.
1922 E. Riverside Dr.
Schramm, Inc.

Newark

C. H. Loomis & Sons Co.
304 Jelliff Ave.
Schramm, Inc.
Wallace & Tiernan Co.
P. O. Box 178

NEW MEXICO

Albuquerque

Lewis O. Kohlaas
322 S. Terrace Ave.
George H. Snell Company
New Mexico Road Machinery Co.
P. O. Box 665
Schramm, Inc.

NEW YORK

Brooklyn

Jos. G. Pollard Co., Inc.
142 Ashland Place
George H. Snell Co.
John Wilfert Co.
George H. Snell Company

Buffalo

Equipment Sales, Inc.
610 Erie Co. Bank Bldg.
Golden Anderson Valve Specialty Co.
Republic Flow Meters Co.
J. H. Roseberry
1211 Genesee Bldg.
Yeomans Bros. Co.
U. S. Cast Iron Pipe & Foundry Co.
957 E. Ferry St.

GEOGRAPHICAL INDEX OF DEALERS AND DISTRIBUTORS

Wallace & Tiernan Co.
Mr. V. J. Harder
446 Marine Trust Bldg.
The Wheeler-Murray Co.
329-331 Ellicott St.
Schramm, Inc.

Horseheads

George D. Case
Schramm, Inc.

New York

E. E. Brereton
Room 513, 51 E. 42nd St.
Peerless Pump Company
Cont. Trading Co., Inc.
232 Fulton St.
McCloskey Torch Company
A. P. Dienst Company, Inc.
Third Ave. and 140th St.
Schramm, Inc.
Representative for South America
W. R. Grace & Company
P. O. Box 286
7 Hanover Square
Peerless Pump Company
G. W. Hoyns
25 Church St.
Golden Anderson Valve Specialty Co.
Wm. R. James Co.
50 Church St.
George H. Snell Company
E. A. Julie
51 E. 42nd St.
Yeomans Bros. Co.
J. J. McCabe
30 Church St.
Automatic Cone Valve Co.
Public Works Equipment Co.
50 Church St.
George H. Snell Company
Public Works Exchange Corp.
40 Exchange Place
George H. Snell Co.
Republic Flow Meters Co.
Rowland & Burns
39 Cortland St.
Economy Pumping Machinery Co.
W. K. Sowdon
342 Madison Ave.
Simplex Valve & Meter Co.
U. S. Cast Iron Pipe & Foundry Co.
71 Broadway
Wallace & Tiernan Co.
A. M. E. Johnstone
2906 Woolworth Bldg.
Water Works Equipment Co.
50 Church St.
George H. Snell Company

Rochester

Construction Specialties Co.
306 Laburnum Crescent
Economy Pumping Machinery Co.

Syracuse

Miller Equipment Co.
127 Solar St.
Schramm, Inc.
Wallace & Tiernan Co.
L. J. Peck
804 James St.

Troy

The E. I. Van Doren Company
206 Times Bldg.
Yeomans Bros. Co.

NORTH CAROLINA

Ashville

Douglas Co.
George H. Snell Co.

Charlotte

J. R. Purser
406 Commercial Bank Bldg.
Yeomans Bros. Co.
Republic Flow Meters Co.
Wallace & Tiernan Co., Inc.
H. F. Davis
2025 Delworth Road, E.

Fayetteville

Cape Fear Supply Co.
McCloskey Torch Company

Greensboro

J. D. Wilkins
W. Lee St. at Glenwood Ave.
McCloskey Torch Company
Schramm, Inc.

Raleigh

Dillon Supply Co.
McCloskey Torch Company

Winston-Salem

Atlas Supply Co.
George H. Snell Co.

OHIO

Akron

Hardware & Supply Co.
475 S. High St.
McCloskey Torch Company

Canton

Quality Hardware Co.
McCloskey Torch Company

Cincinnati

O. J. Allonier
1231 Union Trust Bldg.
Yeomans Bros. Co.
Geist & Murphy
309 Main St.
Economy Pumping Machinery Co.
Hauer Power Equipment Co.
Union Trust Bldg.
Golden Anderson Valve Specialty Co.
Wm. T. Johnston Co.
214 Vine St.
Schramm, Inc.
Republic Flow Meters Co.

Cleveland

Bacon-Hibbard-Eichman, Inc.
917 Central Ave.
Schramm, Inc.
Cleveland Pump & Supply Co.
418 Rockefeller Bldg.
Yeomans Bros. Co.
H. W. Jarrett
Rockefeller Bldg.
Golden Anderson Valve Specialty Co.
Republic Flow Meter Co.
Tomlinson, MacLachlan, Inc.
1601 St. Clair Ave.
Simplex Valve & Meter Co.
U. S. Cast Iron Pipe & Foundry Co.
1150 E. 26th St., N. E.
Wallace & Tiernan Co., Inc.
810 Perry-Payne Bldg.
Wilson & Young
1856 Euclid Ave.
Wemlinger, Inc.

Columbus

E. W. Hawke
297 S. High St.
McCloskey Torch Company
Shartle Machine Co.
359 Dublin Ave.
Golden Anderson Valve Specialty Co.
C. L. Stith Co.
305 Franklin St.
McCloskey Torch Company
The Taylor Tractor Co.
McCloskey Torch Company
Wallace & Tiernan Co., Inc.
Mr. F. P. Fisher
111 E. Norwich Ave.
The W. W. Williams Co.
987 W. Goodale St.
Schramm, Inc.
W. W. Williams Co.
624 Webster St.
Schramm, Inc.

Dayton

Kelso-Wagner Co.
134 W. 2nd St.
Yeomans Bros. Co.

Elyria

Farm Implement Co.
328 Broad St.
McCloskey Torch Company

Lakewood

R. B. Wood & Co.
Vincent McCarthy
1256 Elbur Ave.

Newark

Crane-Krieg-Flory Co.
McCloskey Torch Company

Portsmouth

The Industrial Supply Co.
1515 Tenth St.
Wemlinger, Inc.

Toledo

Bostwick-Braun Co.
Cor. Summit & Monroe Sts.
McCloskey Torch Company
Contractors' Machinery Co.
909 Summit St.
McCloskey Torch Company
W. A. Kuhlman & Co.
340 Water St.
McCloskey Torch Company
Moriarty Bros.
208 Knapp St.
Wemlinger, Inc.
National Supply Co.
P. O. Box 899
McCloskey Torch Company
A. Carle Rogers
752 Euclid Ave.
Yeomans Bros. Co.
Toledo Sales & Engineering Co.
16 N. St. Clair St.
Schramm, Inc.

OKLAHOMA

Oklahoma City

The Boardman Co.
McCloskey Torch Company
Leland Equipment Co.
Schramm, Inc.
Frank Loeffler Supply Co.
710 N. Hudson St.
Economy Pumping Machinery Co.
J. D. Mann Const. Co.
618 Petroleum Bldg.
McCloskey Torch Company
W. J. Pettee & Co.
McCloskey Torch Company
Wallace & Tiernan Co., Inc.
Mr. E. W. Schouten
619 Cotton Exchange Bldg.
Wylie Bros.
McCloskey Torch Company

Tulsa

Leland Equipment Co.
515 W. Archer St.
McCloskey Torch Company
Leland Truck Equipment Co.
30 North Owasso St.
Schramm, Inc.

OREGON

Portland

Consolidated Supply Co.
George H. Snell Co.
M. Donald Spencer
355 Everett St., cor. Eighth St.
Peerless Pump Co.
Gordon & Finkbeiner
222 Pine St.
Yeomans Bros.
Howard-Cooper Corp.
Third and Hawthorne Sts.
Schramm, Inc.
J. L. Latture Equipment Co.
McCloskey Torch Company
Republic Flow Meters Co.
Wm. S. Turner & Co.
Pacific Bldg.
Golden Anderson Valve Specialty Co.

PENNSYLVANIA

Corry

Corry Bridge & Supply Co.
McCloskey Torch Company

Erie

A. H. Brebner & Son
14 East 5th St.
McCloskey Torch Company

Pen Argyl

Quarry Supply Company
Sullivan Machinery Company

Philadelphia

A. R. Amos, Jr.
502 Harrison Bldg.
Yeomans Bros. Co.
G. R. Chambers
Bourse Bldg.
Economy Pumping Machinery Co.
DeHuff & Hopkins
Morris Bldg.
Automatic Cone Valve Co.
Edwin Elliot & Co.
560 N. 16th St.
Golden Anderson Valve Specialty Co.
N. E. Henderson & Son
1320 Race St.
McCloskey Torch Company
Republic Flow Meters Co.
Service Supply Corp.
20th and Venango Sts.
McCloskey Torch Company
U. S. Cast Iron Pipe & Foundry Co.
1421 Chestnut St.
Wallace & Tiernan Co.
Mr. J. B. Kinney
137 S. 50th St.

Pittsburgh

C. C. Behney
718 Empire Bldg.
Simplex Valve & Meter Co.
George H. Snell Company
Bradshaw & Co.
530 Fourth Ave.
Automatic Cone Valve Co.
Bushnell Machinery Co.
1501 Grant Bldg.
Yeomans Bros. Co.
James T. Castle
1601 Arrott Bldg.
Peerless Pump Company
Dravo Equipment Co.
McCloskey Torch Company
Leiendecker Bros.
Fulton Bldg.
Economy Plumbing Machinery Co.
Republic Flow Meters Co.
Schramm, Inc.
331 Fourth Ave.
U. S. Cast Iron Pipe & Foundry Co.
6th and Smithfield Sts.
Wallace & Tiernan Co., Inc.
233 Oliver Ave.
Geo. W. Ziegler Machy. Co.
528 First Ave.
Schramm, Inc.

Reading

Geo. D. Lessig & Son
South Temple
Schramm, Inc.

Sharon

Fruit-Ohl Co.
84 E. State St.
McCloskey Torch Company

Wilkes-Barre

P. F. Gilboy
Bennett Bldg.
Economy Pumping Machinery Co.
Lewis & Bennett Hdw. Co.
McCloskey Torch Company

RHODE ISLAND

Pawtucket

Gallagher & Mooney
318 Main St.
McCloskey Torch Company

Providence

Congdon & Carpenter
McCloskey Torch Company

SOUTH CAROLINA

Columbia

Columbia Supply Co.
823 W. Gervais St.
McCloskey Torch Company
Construction Equipment Company
1213 Lincoln St.
Schramm, Inc.

Greenville

R. P. Sweeny Co.
Chamber of Commerce Bldg.
McCloskey Torch Company
Wemlinger, Inc.

SOUTH DAKOTA

Rapid City

Evans Tractor & Equipment Co.
McCloskey Torch Company
Sullivan Machinery Company

Sioux Falls

Western Material Co.
McCloskey Torch Company

TENNESSEE

Chattanooga

McWhorter Truck & Equipment Co.
300 West Main St.
Schramm, Inc.
Wallace & Tiernan Co., Inc.
Mr. G. R. Kavanagh
634 Tennessee Power Bldg.

Knoxville

Iddins Machinery Company
111 East Jackson St.
Schramm, Inc.
Wallace & Tiernan Co., Inc.
Mr. A. R. Murphy
1214 Holston Bank Bldg.

Memphis

Carloss Well Supply Co.
1116 Front St.
Sullivan Machinery Company
Hoshall Machinery Co.
715 Fidelity Bank Bldg.
Yeomans Bros. Co.
Tri-State Equipment Co.
393 North Main St.
Schramm, Inc.
Sullivan Machinery Company

GEOGRAPHICAL INDEX OF DEALERS AND DISTRIBUTORS

Nashville

Harvill Supply Co.
413 Commerce St.
Schramm, Inc.
Jones & Allen Co., Inc.
111 First Ave., S.
Sullivan Machinery Company

TEXAS

Amarillo

D. L. McDonald
717 Amarillo Bldg.
Peerless Pump Company

Dallas

Browning Ferris Machinery Co.
McCloskey Torch Company
F. C. Crane Company
1301 S. Lamar St.
Schramm, Inc.
C. M. Crookshank
1315 Santa Fe Bldg.
Golden Anderson Valve Specialty Co.
Dillard-Lewis Co.
612 Construction Industries Bldg.
Yeomans Bros. Co.
Republic Flow Meters Co.
Smith & Courtney
2507 Commerce St.
Sullivan Machinery Company
Smith & Whitney
2017 Cedar Springs Rd.
Economy Pumping Machinery Co.
U. S. Cast Iron Pipe & Foundry Co.
Akard and Commerce Sts.
Wallace & Tiernan Co., Inc.
506 Central Bank Bldg.

El Paso

Geo. W. Herlin
1520 Campbell St.
Yeomans Bros. Co.
Francis Wagner
307 San Francisco St.
Schramm, Inc.

Houston

J. R. Christian Co.
1601 Post-Dispatch Bldg.
Wemlinger, Inc.
M. N. Dannenbaum
Bankers Mortgage Bldg.
Simplex Valve & Meter Co.
F. W. Gartner & Co.
3135 McKinney Ave.
P. O. Box 1303
McCloskey Torch Company
Schramm, Inc.
C. C. Saner
703 Keystone Bldg.
Sullivan Machinery Company
S. Texas Imp. & Machinery Co.
Wood & Jacinto
McCloskey Torch Company
Texas Engineering Co.
941 Electric Bldg.
Yeomans Bros. Co.

San Antonio

Alamo Iron Works Co.
30 Santa Clara St.
McCloskey Torch Company
Schramm, Inc.
Dillard-Lewis Co.
Yeomans Bros. Co.

UTAH

Ogden

Wallace & Tiernan Co., Inc.
Mr. L. W. Pingree
427 Kiesel Bldg.

Salt Lake City

Hawley-Richardson-Williams Co.
Dooly Bldg.
Yeomans Bros. Co.
Republic Flow Meters Co.
Water Works Equipment Co.
149 W. 2nd South St.
Simplex Valve & Meter Co.

VIRGINIA

Petersburg

R. D. Wood & Co.
P. G. Bunting
108 S. Syracuse St.

Richmond

Hackley Morrison Co., Inc.
204 N. Jefferson St.
Wemlinger, Inc.
Richmond Machinery & Equip. Co.
12-14-16 North 15th St.
Schramm, Inc.
Virginia Engineering Co.
American Nat. Bank Bldg.
Automatic Cone Valve Co.

Roanoke

Wallace & Tiernan Co.
Mr. J. M. Masterson
318 Mountainview Terrace

WASHINGTON

Seattle

E. R. Bracken
Pantages Bldg.
McCloskey Torch Company
Republic Flow Meters Co.
Steam Appliance Co.
415 Lenora St.
Yeomans Bros. Co.
U. S. Cast Iron Pipe & Foundry Co.
1st and Marion Sts.
Wallace & Tiernan Co., Inc.
Mr. Emerson Dolliver
411 Lloyd Bldg.
Water Works & Power Equip. Co.
White-Henry-Stuart Bldg.
Automatic Cone Valve Co.
Goldern Anderson Valve Specialty Co.
Simplex Valve & Meter Co.

Spokane

Spokane Hardware Co.
McCloskey Torch Company
Wallace & Tiernan Co., Inc.
Mr. Lawrence Sovulewski
724 Realty Bldg., 224 Riverside Dr.

Tacoma

Washington Hardware Co.
McCloskey Torch Company

WEST VIRGINIA

Charleston

Capitol Cy. Supply Co.
McCloskey Torch Company
Capitol Equip. Co.
Bank of Commerce Bldg.
Golden Anderson Valve Specialty Co.
Wallace & Tiernan Co., Inc.
Mr. R. C. Clement
309 Ruffner Ave.
Loewenstein & Sons
McCloskey Torch Company

Huntington

Banks Miller Supply Co.
McCloskey Torch Co.

Parkersburg

Parkersburg Supply Co.
McCloskey Torch Company

Wheeling

Kennedy Hardware Co.
McCloskey Torch Company

WISCONSIN

Milwaukee

Boehck Machinery Co.
2406 Clybourn St.
McCloskey Torch Company
Chadwick Bros. Co.
25th and Clybourne Sts.
McCloskey Torch Company
Cunningham-Ortmayer Co.
15 Michigan St.
McCloskey Torch Company
F. H. Dorner
311 Knapp St.
Simplex Valve & Meter Co.
Geo. F. Fredericks Co.
216 Water St.
Automatic Cone Valve Co.
Kolloge Hardware Co.
3rd St. at Juneau
McCloskey Torch Company
Chas. W. Miller
194 Reed St.
Yeomans Bros. Co.
Republic Flow Meters Co.

WYOMING

Casper

Nicolaysen Lbr. Co.
McCloskey Torch Company

CANADA

Brantford, Ont.

Jordan Roberts Sales Ltd.
Peerless Pump Company

Calgary, Alta.

Bell & Morris
McCloskey Torch Company

Cobalt, Ont.

Northern Canada Supply Co.
McCloskey Torch Co.

Montreal

Darling Brothers, Ltd.
Yeomans Bros. Co.
Engineering Equipment Co.
1072 Beaver Hall Gill
Economy Pumping Machinery Co.
F. Hankin Co., Ltd.
2028 Union Ave.
Simplex Valve & Meter Co.
Mussens, Ltd.
Phillips Place Bldg.
McCloskey Torch Company

Sault Ste. Marie, Ont.

J. M. Biscomb
673 Queen St.
McCloskey Torch Company
Toronto
Darling Bros., Ltd.
Yeomans Bros. Co.
F. Hankin & Co., Ltd.
165 Spadina Ave.
Simplex Valve & Meter Co.
Wallace & Tiernan Co., Inc.
Mr. J. Van Benschoten
Foy Bldg., 32 Front St.

Vancouver, B. C.

Brown-Fraser Co., Ltd.
1150 Homer St.
Schramm, Inc.
Frank Darling & Co.
1142 Homer St.
Yeomans Bros. Co.

Winnipeg

Darling Brothers, Ltd.
Yeomans Bros. Co.
Powell Equipment Co.
1056 Arlington St.
McCloskey Torch Company
Wallace & Tiernan Co., Inc.
Mr. H. C. Lindsten
813 Royal Bank Bldg.

CUBA

Havana

Daniel, Inc.
814 Metropolitana Bldg.
Simplex Valve & Meter Co.
Purdy & Henderson Trading Co.
Havana 55, esquina a Empedrado
Yeomans Bros. Co.

HAWAII

Honolulu

Honolulu Iron Works
Yeomans Bros. Co.

FOREIGN REPRESENTATIVES

ARGENTINA

Buenos Aires

Buxton, Guilayan & Co., Ltd.
Yeomans Bros.

AUSTRALIA

Melbourne

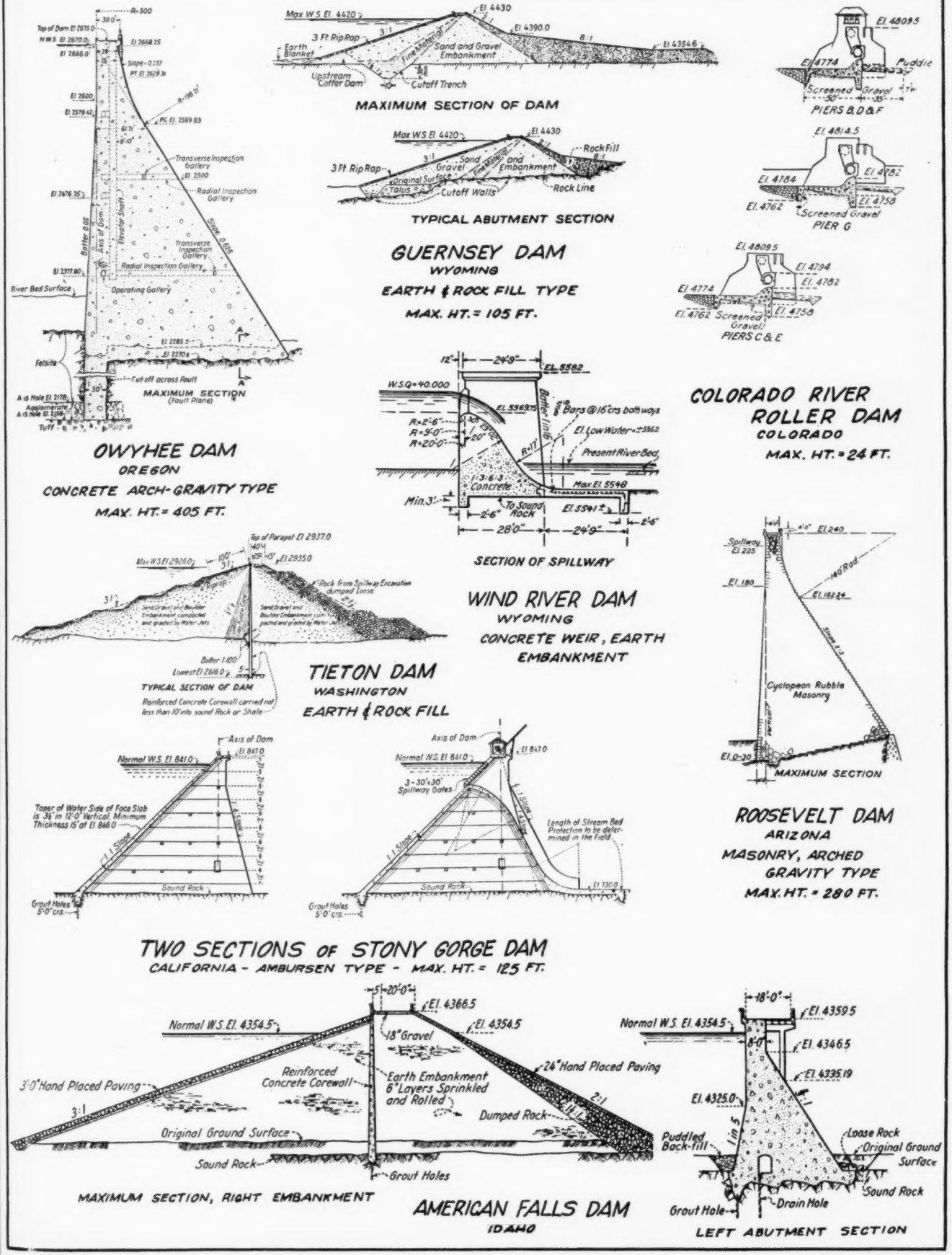
Gibson, Battle (Melbourne) Pty., Ltd.
Yeomans Bros. Co.

JAPAN

Tokio

Okura & Co.
Yeomans Bros. Co.

Sections of U. S. Reclamation Service Dams



Grouting of Dams, Tunnels, Shafts, Etc.

The merits of grouting for the pretreatment of damsites and for the sealing of leakages have been recognized by engineers for many years.

Ordinary Processes.—Grouting is usually carried on by forcing the fluid grout into the voids to be filled by means of gravity or by air pressure. Where fine material is being dealt with, two pipes are driven a short distance apart. Water is pumped down one pipe, and the stream finds its way through the voids or fissures below the surface to the second pipe, through which it escapes to the surface. Once a channel has been formed in this way, cement grout is forced through the same path until grout appears in the outlet pipe. This pipe is then sealed and the effect of further pumping is to force the grout into the material adjacent to the channel, forming a dense, solid deposit of concrete. The deposit may be built up in any direction by driving the pipes at different locations and to different elevations.

Where the material to be grouted is not firmly compacted, or where the voids form a fairly large percentage of the whole, the grout may be introduced simply by driving a row of pipes and pouring the mixture into them. In this case the head furnished by the grout itself will be sufficient to force it through the permeable material. The chief difficulty in grouting coarse material lies in keeping the grout from spreading too far from the point of introduction, or beyond the confines of the territory it is wished to solidify. In the event such conditions are met with, the grout should be introduced a little at a time and the successive accretions allowed to set before more is placed. Thus a shell partially enclosing the region to be grouted is built up, and the deposit may be completed with as much rapidity as the grout will flow away through the interstices of the material.

Dry grouting of sand has been experimented with, but this scheme is seldom employed at present. This process requires a pipe, drawn to a point at the lower end, which is perforated with holes about ⅜ in. in diameter. The pipe is connected to a source of compressed air at its upper end, and cement is fed into the pipe by means of an injector. The cement is carried into the sand through the holes in the pointed end of the pipe, where the action of the escaping air is to mix sand, cement and water into a mortar which solidifies into a firm mass. The grouted region is extended by raising the pipe and by moving it to a new location.

Francois Cementation Process.—This process was developed by Albert Francois and the Francois Cementation Co., of London, operates under his patent. The term "cementation" denotes movement of the grouting mixture directly by means of pump pistons. Compressed air is not used, and the liquid cement is carried by the extremely high pressures under which it is driven, into the finest fissures and cracks in such a way as to unite the materials into an impermeable mass.

The pumps used are capable of quickly developing pressures up to 3,000 lb. per square inch. The cement column is moved continuously, and it is claimed that control is simple and flexible. The cement tanks and pumps may be located hundreds of feet away from the point of application, resulting in few movements of the plant while a wide territory is being covered. Chemicals are employed as lubricants to insure the carrying of the grout into the finest fissures and cracks.

The methods of the Francois Cementation Co. are the result of many years' study of the problem of cement grouting. They are responsible for the repairs to St. Paul's Cathedral in London and the foundation treatment of the famous Leaning Tower of Pisa. In addition they have treated dam sites all over Europe and have corrected defects in many existing dams. The Francois has also been found efficacious in sealing leakages in shafts and tunnels, as well as in the pre-treatment of strata to permit dry excavation, and the strengthening of foundations to prevent vibration and subsidence has been repeatedly carried out.

By means of an arrangement with the Francois Cementation Co., the Dravo Contracting Co., of Pittsburgh, Pa., is granted the use of the Francois patents on this continent. A staff skilled in the application of the process has joined the Dravo organization, under the direction of Maj. J. S. Crawhall, who has had charge of some of the largest cementation shaft-sinking jobs in England. A number of application of the Francois process have already been made in this country.

Asphalt Grouting.—A process of grouting employing liquid asphalt has been developed by George W. Christians, a Chattanooga, Tenn., engineer. This method is practiced, under patents, by the American Asphalt Grouting Co. of Chattanooga.

The principle of operation involved in asphalt grouting is the pumping of a materiai which is fluid when hot, but not absolutely solid when cooled—such as asphalt—down through electrically heated pipes placed in drilled holes, into the crevices in the rock below. When the asphalt leaves the pipe and touches the water it congeals on the outside into a nearly solid condition. In this state it is tough enough to resist the pressure of a moving stream of water, but soft enough so that a moderate pressure from the pipe line can expand it from the inside until it fills and effectually seals the crevices against the flow of water.

It is necessary that the material be an insulator of electricity, a poor conductor of heat and insoluble in water. It must melt at a moderate temperature and when cold it must be stiff enough to resist whatever water pressure may be encountered. At the same time it must be ductile enough so that a heavier pressure from the pipe line will slowly expand it into the crevices so as to make intimate contact with the rock surfaces. Asphalt fulfills all of these requirements very well. In addition, when so placed it is as permanent as the rock itself.

The apparatus required is simple and inexpensive. A heating kettle for melting the asphalt and a small, adjustable-stroke piston pump driven by a 1-hp. motor are required for handling the asphalt to the pipe line. The pipe is usually 1½ in. extra heavy throughout the upper portion, while that in the crevice-bearing rock is 1½-in. standard weight pipe perforated by ¾-in. holes. It is heated by an iron resistance wire which enters through an insulated stuffing box at the top and is held in the center of the pipe by suitable insulators at the pipe couplings. The wire is fastened electrically and mechanically to the pipe at the bottom. The electrical circuit passes down the wire and back up the pipe. The wire is kept taut by tension springs at the top. As mentioned above, patents have been secured covering the method and apparatus.

In operation the pipe may be surrounded by water and thereby kept so cool that the asphalt touching it is solid. However, the heat conductivity of the asphalt is such that a fluid passage is easily maintained next to the hot wire in the center so that the pressure is equalized from top to bottom of the pipe. The asphalt is free to emerge at any of the several cavities which may exist throughout the extent of the perforations, and when back pressure is built up, a definite assurance is obtained that all crevices encountered by this hole are filled.

The heating device not only keeps the asphalt in a fluid condition until it reaches the cavities to be filled, but also makes it possible to resume operations after a shutdown merely by applying the heat for a few minutes before starting the pump.

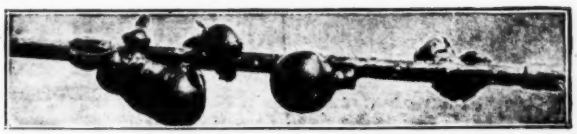
THE AMERICAN ASPHALT GROUTING CO.

Chattanooga, Tennessee

Licensed under Christians Asphalt Grouting Patents

European licensee: FRANCOIS CEMENTATION CO., Ltd., Doncaster, England

Leakage of water through rock, masonry, concrete, gravel, etc., can be stopped more surely and economically by Asphalt Grouting than by any other method.



Asphalt Emerging from Pipe

Hot fluid asphalt is pumped through electrically heated pipes placed in drilled holes intercepting the cracks or crevices to be filled. When the asphalt leaves the pipe and touches the water it congeals on the outside into a nearly solid condition which is tough enough to resist the pressure of a moving stream of water, but soft enough so that a moderate pressure from the pipe line can expand it from the inside until it fills and effectually seals the crevice against the flow of water.

This process has been applied successfully to a number of difficult and important jobs during the past four years; and all operating problems thoroughly worked out. Some outstanding advantages of Asphalt Grouting are:

(1) Holes can be drilled to full depth in one operation through any number of cavities.

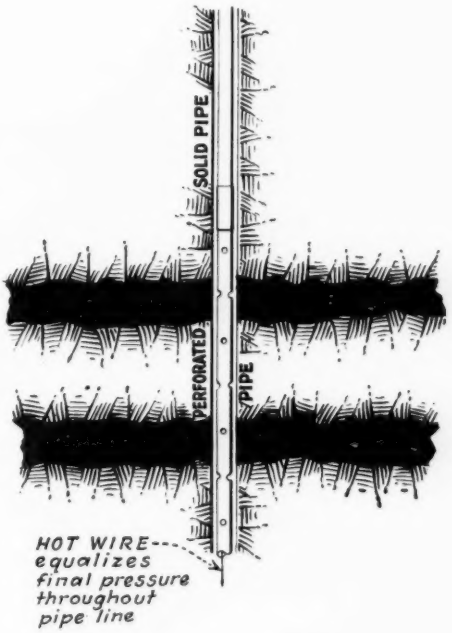
(2) All cavities will be filled with equal effectiveness.

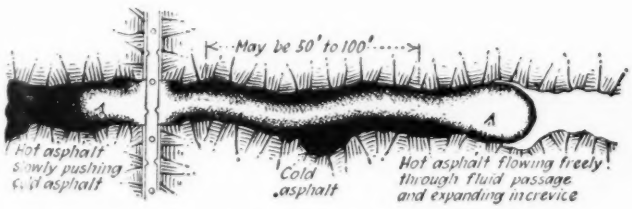
(3) No asphalt is wasted by dilution or washing away.

(4) Movement of asphalt away from pipe line is ample, but easily controlled, so that closure is effected with minimum excess material.

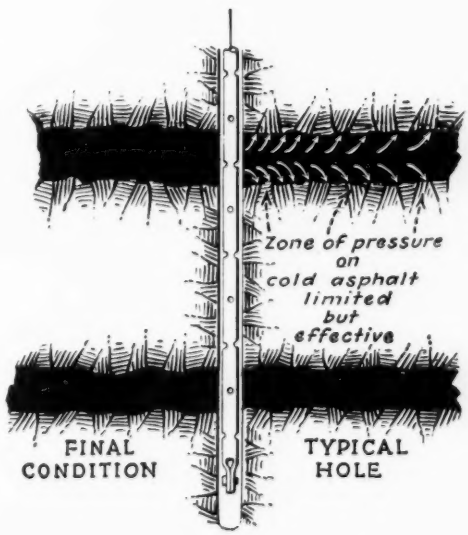
(5) Final pressure gives absolute assurance that all cavities pierced by the drilled hole are filled.

Further information on request




May be 50' to 100'
Hot asphalt slowly pushing cold asphalt
Cold asphalt
Hot asphalt flowing freely through fluid passage and expanding in crevice

Hot Asphalt Expanding in Typical Crevice



Trenching by Machine and by Hand

Excavating with Small Trenching Machine

The following comparison of costs by machine and hand methods was given by H. S. Greene, Vice-President, Barber-Greene Co., in a paper presented at the 1928 convention of the American Water Works Association:

A small trench machine is a machine to cut about 24 in. wide and capable of digging from 6 to 8 ft. deep.

Advantages of Small Machines.—The need of a small trench machine is much more apparent today than it was several years ago. Then all mains were placed in the roadway, but today many engineers are recommending that they be put in parkways or alleys. Where this practice is followed, the small machine is the answer for excavating ditch. There is also another factor which influences one to consider the small machine, and that is the shortage of common labor. A small trench machine will do the work of 30 to 50 men.

The small machine was originally designed for city conditions, but is able to give a very good account of itself on long distance cross-country work, where the machine is quite often operated 24 hours per day and where dependability is a matter of prime importance.

Cost of Operation.—Having considered the general specification of a small trench machine, the next problem is to analyze the cost of digging ditch. Results submitted by scores of users indicate a wide variety of methods in securing costs. For example, in the matter of depreciation, one contractor insists on writing off the whole cost of the ditcher on his first job. Occasionally a public utilities organization will take the opposite extreme and figure a 15-year life. Perhaps an average of these two is a fair depreciation and may be taken as five years.

In the item of interest on the investment, there is not much variation, as 4 per cent of the purchase price extending over the life of the machine is close enough for practical purposes.

Repairs can be determined with some accuracy by examining records for previous years, but any estimate for the coming season is at the best merely a guess. It is possible, however, to determine some sort of average from various reports which have been turned in by the owners of small machines. Expressed as a percentage of the purchase price, this can be used in estimating the cost of future work, assuming that no serious accidents will be encountered which will run the repairs beyond the average. This item should include the cost of all parts purchased, the cost of machine shop work, the cost of work by mechanics other than the operator, and even the cost of the operator's time when the work is done between jobs. This item should not include the operator's time for making ordinary adjustments or replacement of parts on the job, because his time will show straight through as that of the operating expense. As near as can be estimated, the repairs on a small machine, including the digging teeth, may be expected to run from 8 to 14 per cent of the purchase price.

An estimate based on a 5-year life carrying 6 per cent interest on the investment, including repairs of 12 per cent, will figure about $15 per day. This can be said to represent the overhead expense of operating a small machine. The daily operating expense, of course, can be determined exactly, using the operator's wages, plus gasoline and lubricating oil. In many conditions, a helper will increase the amount of ditch dug per day sufficiently to pay his wages many times over. Gasoline consumed will vary from 1 to 2½ gal. per hour, and oil and grease might be said to be a dollar a day. This is very liberal, and from these it will be found that the total operating charge per day will be about $10, or possibly a little higher is a helper is used. This makes the total cost for operating a machine about $25, or possibly $30 per day.

In reducing these figures to a cost-per-foot basis, the most important item, of course, is the amount of trench dug per day. This may vary through a very wide range. The amount of trench dug per day may be limited by the laying of pipe, and the amount dug will also vary on account of material. For example, 400 ft. in a caliche formation might be considered a good day's work, whereas 6,000 ft. a day in top soil is possible where the digging is easy and only 30 in. deep. Between these two extremes there is such a variety of widths, depths, and conditions of soil that an expert would have to be called in if it is desired to have a fairly close estimate of cost in advance. Even then there may be a large discrepancy between the estimate and the actual costs, due to the difficulty of determining the conditions underground.

After varying the different factors to meet local conditions, the worst circumstances give $35 per day to operate a small machine. Assuming that only 500 ft. of trench is dug per day, the cost would be 7 ct. per foot. After checking this up with actual cost records submitted by various water-works organizations, a fairly close relation is noted.

Costs on Specific Jobs.—One machine working in San Antonio cut ditch at a cost of 5 ct. per feet. This was in a particularly hard formation, where even with cheap Mexican labor, hand work cost 40 ct. per foot. In Houston, a trench 21 in. wide and 5½ ft. deep cost 7 ct. per foot. In Oakland, Calif., a ditch 18 in. wide and 3½ ft. deep was cut for 4½ ct. per foot. In Chicago, Ill., a ditch 18 in. wide and 4½ ft. deep was cut for 4½ ct. per foot. In Shreveport, La., a ditch 18 in. wide and 5½ ft. deep was cut for 5½ ct. per foot.

In Norman, Okla., the machine paid for itself in cutting 34,000 ft. charged at 10 ct. per foot for all of the work. This machine also did work for the sewer department, gas company and telephone company. The city of Thomasville, Ga., reports costs as low as 2¾ ct. average for water ditch, and 4½ ct. per foot for sewer ditch.

Cost Per Cubic Yard.—Converting lineal foot costs to costs per cubic yard gives interesting information. Some records of cross-country work show 5 ct. per yard but, of course, this is an extreme. Again, records show costs as high as $1.16 per yard, but one might assume something was wrong here. After checking a large number of records and

Cost of Excavating Small Ditches, Machine Versus Hand Method

	Location and Nature of Soil	Width of Trench in In.	Depth of Trench in In.	Total Job Footage	Total Cost	Trench Cost per Foot	Hand Work Cost per Foot	Saving per Foot	Total Saving	Remarks
1	Streets, all kinds of soil	12	42	56,231	.....	$0.063	.....	.....	.....	Average for
2	Streets, all kinds of soil	12	42	176,076	.....	.065	.....	.....	.....	3 machines
3	Streets, very rocky.....	18	44	35,047	.....	.081	.....	.....	.....	Gas Co.
4	Streets, very rocky.....	16	48	18,570	.....	.051	.....	.....	.....	Telephone
5	Streets and parkways, hard-pan and clay.....	18	60	100,000	.....	.075	.....	.....	.....	Water
6	Boulders, clay and sand	18	48	110,415	.....	.038	.....	.....	.....	
7	Hard-pan	....	....	39,000	.....	.072	.....	.....	.....	Water
8	In parking, no hard dirt	18	42	9,110	$463.09	.05	$0.22	$0.17	$1,169.51	.....
9	In parking, no hard dirt	18	48	456	28.34	.08	.23	.15	53.03	.....
10	In parking, no hard dirt	18	66	200	18.89	.09	.38	.29	57.92	.....
11	In parking, no hard dirt	18	60	325	20.14	.06	.32	.26	84.22	.....
12	In parking, no hard dirt	18	38	1,553	109.52	.07	.26	.19	290.04	.....
13	Surfaced street, loam....	18	42	2,451	104.28	.04	.19	.14	354.80	.....
14	Paved street, loam.....	18	36	104	8.68	.04	.16	.13	13.37	.....
15	Unsurfaced, hard dirt....	18	42	3,850	222.32	.08	.20	.12	344.56	.....
16	Unsurfaced, hard dirt....	18	48	424	25.14	.06	.19	.13	57.04	.....
17	Surfaced, hard dirt.....	18	42	1,229	139.11	.11	.19	.08	99.69	.....
18	Surfaced, hard dirt.....	18	48	233	29.86	.13	.32	.19	45.32	.....
19	Surfaced, hard dirt.....	18	60	100	14.55	.15	.34	.19	19.36	.....
20	Surfaced, hard dirt.....	18	42	4,261	459.32	.10	.27	.17	665.27	.....
21	Paved street, hard dirt	18	36	195	19.71	.10	.19	.09	18.06	.....
22	Surfaced, rocky soil.....	18	42	693	64.01	.09	.33	.24	160.99	.....
23	Surfaced, hard dirt.....	18	42	209	24.66	.12	.32	.20	43.20	.....
24	Resurfaced, rocky soil....	18	42	700	57.20	.08	.32	.24	169.88	.....
25	Paved street, hard dirt..	18	48	363	28.94	.08	.22	.14	49.47	.....
26	Paved street, hard dirt..	18	42	424	37.83	.09	.32	.23	99.81	.....
27	In parking, no lawn, rocky soil	18	42	164	12.70	.08	.32	.24	40.49	.....
28	In parking in lawn, rocky soil	18	48	397	31.06	.08	.19	.11	44.03	.....
29	In parking in lawn, rocky soil	18	42	300	20.21	.07	.22	.15	44.73	.....
30	In parking in lawn, hard dirt	18	48	231	22.35	.09	.21	.12	27.20	.....

omitting from the summary those that were incomplete, the cost is about 25 ct. per cubic yard for excavation.

Results Obtained.—Whether users, in figuring the probable cost of work in advance, follow the percentages and unit costs outlined above more or less closely, is not known, but certainly, reports indicate that in figuring the cost of jobs after completion of the work these users deviate quite markedly.

In the matter of interest, it is found that users are quite likely to figure 6, 7 or 8 per cent of the total purchase price; at least for the first year, instead of taking an average over the life of the machine and figuring 4 per cent on the purchase price.

The total overhead as reported by the various users shows very little variation, running from $10.30 per day to $12.20 per day, with the exception of one user who placed a heavy depreciation against a 70-day job. This makes the overhead total $19.16 per day.

Under the heading of operating expense, the results of four users agree very closely, varying from $7.16 to $8.09 per day. Two other users show $12.65 and $12.91 per day and in one of these cases it is known that the high rate is due to the fact that the operator and helper were permitted to remain idle when the machine was not digging, or in case they were put on other work, their pay was still charged against the ditching job. The figures indicate that on city work the ditchers are idle about one-third of the time, waiting for the pipe-laying gang to catch up, or for other reasons not traceable to the machine, and some users state that under such conditions the operator and helper have definite jobs to which they return until the machine is again needed.

In one case the operating expense is shown as $20.80, which may be due largely to charging idle time of the operator and helper against the machine, and is also due to a rather excessive moving charge made up of the time of a truck and trailer moving the ditcher from one job to another.

In spite of these few discrepancies in the matter of figuring costs, it happens that in two of the three cases, the job showing the largest charges per day also shows the largest average distance dug per day, so that the costs per foot of trench are not far out of line. In fact, the job which shows $12.65 per day operating expense shows the lowest cost per foot, namely, 3.8 ct. The costs vary from this figure to 8.1 ct. This is a job averaging only 3 ft. 8 in. deep, but the digging is described as very hard.

A tabulation of costs is reproduced. While most organizations are willing to discuss these matters of cost with individuals and companies, some are not willing to have their costs broadcast, so that names are omitted.

Trenching with Power Shovel

Methods used at New Bedford, Mass., that resulted in a large saving over hand labor methods were described as follows in *Water Works* by Stephen H. Taylor, Superintendent, Water Department, New Bedford, Mass:

The replacing of hand labor by machinery on the larger jobs is interesting as showing how much can be done by that method with a few men.

The New Bedford Water Works contemplated laying 6,600 ft. of 36 in. cast iron pipe, in addition to the ordinary annual extensions which are necessary to keep pace with new building operations constantly creeping out beyond the limits of existing mains.

Labor was very scarce; to say nothing of the excessively high wages demanded.

It was decided to purchase a 14B Bucyrus steam shovel with an extended dipper arm and a special trenching dipper of half yard capacity, which permits the digging of a trench with perpendicular sides and sufficient depth. We afterward used a ⅝-yd. dipper on the same machine with good results for the wider trenches.

The shovel travels over the trench on platforms made of 10x10 in. or 12x12 in. green oak timbers made up in sections. These sections are long enough to give a good bearing on the sides of the trench and about 6 or 7 ft. wide. Three or four sections are used and the shovel quickly picks up the section behind and places it ahead as the work progresses.

Work was started on a line of 48-in. cast iron pipe about 19,000 ft. long. This work was located 8 to 11 miles from the center of the city and the laborers had to be either boarded near the job or transported to and from the city each day.

In order to facilitate handling the pipe, which weighed 4 to 4½ tons each, a 14Z Bucyrus "Clamshell" and derrick, mounted on caterpillar traction, was purchased. With this outfit and gasoline driven air compressors for handling ledge and large boulders, and gasoline-driven pumps for handling water in wet trenches, the work was accomplished by a crew of from 15 to 20 men and two or three trucks with dump bodies.

The shovel traveled over the trench on platforms, as previously described, depositing the excavated material into trucks which dumped it into the back fill close by. The derrick closely followed the shovel, thus keeping the haul from the track to a minimum.

With the outfit described above and reasonably good earth conditions from 120 to 180 ft. of trenching, pipe laying and backfilling per day was accomplished. The crew was so small that transportation to and from the job daily was an easy matter.

Some sections of the work were in sand, too soft to carry the steam shovel over the trench. Under that condition the excavating was done by a clamshell bucket on the derrick, laying alongside the trench. The banks were so slippery that it sometimes required quick work to get a pipe in the trench before the bank slid in.

The work, with the exception of a little filling in of a low section which was completed early in the third season, was completed in two seasons, laying off during the winter months.

All sorts of earth conditions were encountered: hard pan, with large boulders, quicksand, dry, sliding sand and even swamp where pile driving was necessary. The same derrick with the 30-ft. boom made an excellent pile driver.

I can heartily recommend the above described outfit to anyone having a big job of pipe laying to do.

The cost of the two jobs described was as follows:

Cost of 48-In. Main Laid in 1921, 1922, 1923
Class "B," "C," "D," N.E.W.W.A.

Pipe—$46.50 per ton, 18,813 ft.
Specials—$130 per ton.

	Total	Per Ft.
Pipe and specials	$326,096.04	$17.33
Gates, hydrants and checks	13,055.06	.69
Leadite and gasket	6,364.32	.34
Tools*	29,173.31	1.56
Labor (see sub-division)	93,705.33	4.98
Lumber	4,551.11	.34
Fuel, oil and grease, etc.	7,205.01	.38
Consulting engineering	1,179.76	.06
Replacing road surface	8,929.56	.47
Miscellaneous expense: Traveling, telephone, telegraph, printing, accident, etc.	5,535.30	.29
	$495,574.80	$26.34

*Includes new tools purchased which are still in good condition to the value of $18,940.05, or about $1.00 per foot.

Labor may be divided as follows:

	Total	Per Ft.
Excavating, laying, backfilling, grading and watchman	$84,598.48	$4.50
Unloading and distributing pipe	6,906.52	.37
Tools	1,574.48	.08
Preliminary work	625.85	.03
	$93,705.33	$4.98

Cost of 36-In. Main Laid in 1920, 1921
Class "D," N.E.W.W.A.

Pipe—$64 per ton, 6,846 ft.
Special—$145 per ton.

	Total	Per Ft.
Pipe and specials	$121,191.85	$17.70
Hydrants and gates	6,052.25	.88
Leadite and gasket	1,441.85	.21
Labor	33,139.98	4.84
Fuel, oil, grease	330.34	.05
Lumber	502.90	.07
Miscellaneous	371.50	.06
	$163,030.76	$23.81

We have used the shovel for some of the smaller jobs in the city; but for short lines scattered in various sections of the city it does not pay, as the cost of moving long distances is excessive.

Another interesting feature of the laying of the 48-in. cast iron pipe was laying a curve of approximately 14° or 1,740-ft. radius with straight pipe. It was pronounced by all who saw it as a pretty piece of pipe laying, and was perfectly tight when the water was turned on. This curve was in swampy country and mostly laid above the surface

PERFORMANCE OF TRENCHING MACHINE—MACHINE VERSUS HAND METHODS

Trench Excavation—Nature of Soil	Width of Trench in In.	Depth of Trench in Ft.	Trench Dug, Ft.	Machine	Machine: Labor Cost	Machine: Man-Hours	Machine: Fuel Cost	Machine: Repair Cost	Machine: Freight or Drayage	Machine: Interest	Machine: Depreciation	Machine: Total Cost	Machine: Cost per Trench-Ft.	Hand Work: Man-Hours	Hand Work: Labor Cost	Hand Work: Tool Expense	Hand Work: Total Cost	Cost per Foot	Saving per Trench-Ft.	Total Saving
In parking—no lawn, hard dirt	18	3.5	9,110	383	$181.87	164	$58.30	$95.00	.....	$42.64	$85.28	$463.09	$0.05	4,354	$1,883.18	$139.42	$2,022.60	$0.22	$0.17	$1,159.51
In parking—no lawn, hard dirt	18	4	356	30	12.94	10	3.60	4.00	.....	2.60	5.20	28.34	.08	166	72.87	8.50	81.37	.23	.15	63.03
In parking—no lawn, hard dirt	18	5	325	16	8.00	8	2.40	3.50	.....	2.08	4.16	20.14	.06	223	97.56	6.80	104.36	.32	.26	81.22
In parking—no lawn, hard dirt	18	5.5	200	16	8.00	8	2.40	2.25	.....	2.08	4.16	18.69	.09	160	70.00	6.80	76.80	.30	.29	57.91
In parking—no lawn, hard dirt	18	3.2	1,553	84	42.18	40	18.14	18.00	.....	10.40	20.80	109.52	.07	835	365.55	34.00	399.55	.26	.19	290.05
In surfaced street, loam	18	3.5	2,451	92	41.55	41	13.75	17.00	.....	10.66	21.32	104.28	.04	992	428.88	30.20	459.08	.19	.14	354.80
In paved street, loam	18	3	104	3	1.40	1	.50	1.00	.....	.26	.52	3.68	.04	37	16.20	.85	17.05	.16	.13	13.37
Unsurfaced street, hard dirt	18	3.5	2,850	136	72.00	68	19.38	49.37	$29.55	17.34	34.68	222.32	.08	1,204	526.96	40.22	567.18	.20	.12	344.36
Unsurfaced street, hard dirt	18	4	424	16	8.00	8	2.08	7.35	1.59	2.04	4.08	25.14	.06	175	76.34	5.84	82.18	.19	.13	57.04
Surfaced street, hard dirt	18	3.5	1,229	104	52.00	52	14.38	21.29	11.66	13.26	26.52	139.11	.11	526	221.23	17.57	238.80	.19	.08	99.69
Surfaced street, hard dirt	18	4	233	24	12.00	12	2.40	4.04	2.24	3.06	6.12	29.86	.13	160	69.90	5.34	75.24	.32	.19	45.38
Surfaced street, hard dirt	18	5	100	12	6.00	6	1.12	1.73	1.11	1.53	3.06	14.55	.15	72	31.50	2.40	33.90	.34	.19	19.35
Surfaced street, hard dirt	18	3.5	4,261	232	113.50	116	47.69	87.00	32.00	59.71	119.42	459.32	.10	2,389	1,045.40	79.79	1,125.19	.27	.17	665.87
Paved street, hard dirt	18	3	195	16	8.00	6	2.40	3.37	1.35	1.53	3.06	19.71	.10	80	35.10	2.67	37.77	.19	.09	18.06
Surfaced street, rocky soil	18	3.5	693	44	22.00	22	5.76	.....	11.03	8.41	16.81	64.01	.09	512	207.90	17.10	225.00	.33	.24	160.98
Surfaced street, hard dirt	18	3.5	209	16	8.00	8	3.48	.....	4.01	3.06	6.11	24.66	.12	155	62.70	5.16	67.86	.32	.20	45.20
Unsurfaced street, rocky soil	18	3.5	700	38	19.00	19	6.89	.....	9.53	7.26	14.52	57.20	.08	516	209.85	17.23	227.08	.32	.24	169.80
Paved street, hard dirt	18	4	363	20	10.00	10	2.47	.....	5.01	3.82	7.64	28.94	.08	178	72.45	5.96	73.41	.22	.14	49.47
Paved street, hard dirt	18	3.5	424	22	11.00	11	8.70	.....	5.52	4.20	8.41	37.85	.09	313	127.20	10.44	137.64	.32	.23	99.81
In parking—no lawn, rocky soil	18	3.5	164	8	4.00	4	2.10	.....	2.01	1.53	3.06	12.70	.08	121	49.15	4.04	53.19	.32	.24	40.69
In parking—no lawn, rocky soil	18	4	397	20	10.50	10	4.09	.....	5.01	3.82	7.64	31.06	.08	171	69.40	5.69	75.09	.19	.11	44.03
In parking—no lawn, rocky soil	18	3.5	300	14	7.00	7	1.68	.....	3.51	2.67	5.35	20.21	.07	148	60.00	4.94	64.94	.22	.15	44.73
In parking—no lawn, hard dirt	18	4	231	12	6.00	9	1.52	.....	4.51	3.44	6.88	22.35	.09	100	46.20	3.35	49.55	.21	.12	27.20
In parking—no lawn, hard dirt	18	3.5	224	10	5.00	5	1.05	.....	2.51	1.91	3.82	14.29	.06	110	44.80	3.69	48.49	.22	.16	34.20
Surfaced street, hard dirt	18	3.5	1,110	80	54.00	40	15.90	15.90	5.59	17.79	35.57	144.75	.13	1,268	565.00	42.35	597.35	.54	.41	455.21
Surfaced street, hard dirt	18	4	6,639	415	234.00	208	74.38	69.10	29.04	92.48	184.77	683.97	.10	7,584	3,319.50	253.30	3,572.80	.54	.44	2,888.83
Surfaced street, hard dirt	18	4.5	202	16	9.00	8	2.30	2.65	1.12	3.56	7.11	25.74	.13	231	101.00	7.72	108.72	.54	.41	82.98
Totals			35,047	1,880	$966.94	901	$318.86	$402.55	$167.90	$323.14	$646.07	$2,825.05	$0.08	22,780	$9,865.82	$761.37	$10,627.19	$0.30	$0.22	$7,804.14

DITCHER COSTS FROM DETAILED REPORTS FROM OWNERS

Year Bought	Age When Costs Figured	Width in In.	Depth in Ft.	Type of Soil	Number of Working Days	Total Dug in Ft.	Speed of Digging	Total Investment	Overhead Per Cent of New Delivered Price: % Depreciation	% Interest	% Repairs Including Teeth	% Total Overhead	Operating Expense—Dollars per Day: Per Year	Per Working Day	Operator	Helper	Gas	Oil, Grease, Miscellaneous	Total	Total Daily Expense Over head and Operating	Average Dug per Day in Ft.	Cost in Ct. per Ft.
1924	2 months	9	4	Sand-clay soil, boulders in clay..	52	46,231*	36 in. a min.	$12,600*	9.9	3.2	0.14	13.24	$ 557.00§	10.70§	11.10*	8.67*	3.80*	0.71*	8.09‡‡	18.79	297	6.34
1925	1 year	9	4	Sand-clay soil, boulders in clay..	196	176,076*	36 in. a min.	12,600*	37.7	11.7	3.4	52.8	2,210.00	11.30	10.40*	8.71*	3.14*	1.66*	7.97‡‡	19.27	300	6.5
1924	1 year	18	3⅜	Loam, hard dirt, rocky soil	112½	35,047		4,866	13.3‖	6.7‖	8.3‖	28.3‖	1,371.76‖	12.20	8.60	§§	2.82	1.49	12.91	25.11	311	8.1
1926	2 months		4		54	18,570		5,600	7.7¶	2.17	0.04¶	9.91¶	555.50¶	10.30	2.17	1.34	1.64	2.02	7.16	17.46	344	5.08***
1925	2 years	18	5	Boulder clay with some sand loan; 50% hard digging	400†	100,000		5,450	24.0	3.5	13.75	41.25	2,250.00	11.25	5.00	.....	2.50	‖‖	7.50	18.75	250	7.5
1927	7 months	18	4	Boulder, clay and sand	178‡	110,415		5,500	20.0**	8.0	7.0	35.0	1,925.00	10.80	6.30	4.50	1.46	0.39	12.65	23.45	620	3.8
1927		18	5	10,000 ft. in hard pan	70	39,147		5,950	12.7††	3.8	6.0	22.5	1,341.00	19.16	7.70	3.21	1.72	8.17¶¶	20.80	39.96	559	7.2

*Total for three ditchers.
†Estimated.
‡1,603 hours.
§Each ditcher.
‖Ten months.
¶Two months.
**Barber-Greene figure, reported by owner as 3 per cent.
††One job.
‡‡One ditcher.
§§Included in expense for operator.
‖‖Included in expense for gas.
¶¶This includes large charge for
***In publication of the Iowa State College, Vol. XXVI, No. 34, page 17, reads 5.80 in error.

of the swamp. It was well braced to prevent the joints from blowing out.

Practically all the joints on both the 36-in. and 48-in. lines were made with leadite and braided jute packing, which resulted in a great saving of labor, especially in wet trenches, where the digging and maintaining of larger bell holes would have entailed much more labor and expense.

As an illustration of the difference in cost of joints made with lead and leadite; two lead joints were made at a cost for packing, lead and labor of $18.06 each, whereas the same items for leadite joints cost about $4.42 each. It took three men one hour and forty minutes to make a lead joint, whereas the same three men averaged from six to eight joints per hour with leadite. This does not take into account the extra cost for bell holes when lead joints are made.

Cost of Trenching by Hand

The following cost data on the construction of a small sewer, the trenching for which was done by hand, was given in *Municipal News and Water Works* by Samuel Vadner, Engineer, Wilmington, Del.:

The Oak Grove sewer starts from the septic tank of the Oak Grove School, Elsmere, Del., and runs 1,285 ft. to Chestnut Run, discharging in the open stream. It is wholly a sanitary sewer, handling the discharge from the septic tanks only, except for some rain water from the Oak Grove School at the upper end, which was included with the idea that this water would act as a flushing stream for the sewer. The upper 700 ft. of the sewer is 8-in. T. C. pipe and the lower 585 ft. is 10-in. T. C. pipe, all with cemented, wiped joints and laid to a uniform grade of 9 in. per 100 ft. There are 6 brick manholes.

General Features.—The job was awarded to the lowest bidder, who was 15 per cent under his next competitor. The low bid was due to insufficient previous experience of the contractor at this phase of contracting, as a result of which he did not figure the estimate accurately. All digging was done by hand, using colored labor working a 10-hour day at $0.40 per hour. Five weeks were required to complete the work. The average depth of the trench was 6½ ft. The subsoil was red clay with occasional stratas of water-bearing gravel. Only a slight amount of trouble was occasioned by water, and this was chiefly after two heavy rains. Approximately 800 cu. yd. of dirt were excavated, including that for manholes.

An 18-ft. concrete base road was dug through, as was a double line of street car tracks. Except for 200 ft. of the line along the edge of a field, the balance of the distance was along two cinder topped dirt roads. Due to the solid nature of the ground it was unnecessary to sheet any of the trench. The average width of trench was 30 in., although specifications would allow a minimum of 6 in. on either side of a pipe bell which would result in a minimum width trench at the bottom of 24 in. for 8-in. pipe and 26 in. for 10-in. pipe.

Explanation of Cost Items.—The contractor lost $398.96 on this job, or 15 per cent of the total contract price of $2,644. The loss did not include some small further overhead loss such as interest on money, office expense, etc. However, of the labor charged under the heading of "foreman" $72 was done by a brother of the contractor, who drew no pay, but worked only for a share of possible profits. Of "equipment hire" only the items of $15 for use of the air compressor and drill, and $5 for centrifugal pump hire, were paid out in full, as the remaining equipment belonged to the contractor and would probably have stood idle if not used on this job. For the purpose of job cost accounting the equipment is charged against the job at current renting rates for the same or similar equipment. Of the remaining $252 charged as "equipment hire" probably $60 represented a profit to the contractor using his equipment on this job rather than have it idle. This $60 contingent credit plus the $72 labor credit would reduce the contractor's loss to $267, or 10 per cent. As there were 15 houses along the line of the new sewer, the contractor expected to get a number of profitable small jobs without much competition installing septic tanks for these houses and connecting them to the new sewer. Only one house owner had this done while the main sewer was being put in and the profit from this source was negligible.

The job included at the lower end a 60-ft. concrete retaining wall containing 17 yd. of 1:3:5 concrete.

The cost of the work was divided as follows: Labor 69.2 per cent, material 21.0 per cent, equipment hire 8.8 per cent, insurance 1 per cent. From observation five-eighths of the laborer's cost of $1,172, or $1,070, was for excavating, some dirt being handled twice, due to the depth of trench.

Conclusions.—The labor cost precluded the contractor from any chance for profit. There was a trench digging machine within a few miles which could have been hired to dig all the trench, except the street and car track crossing. The only pipes encountered were two 1-in. gas pipes. A trench machine could have cut 1,200 ft. in 10 working days at a rental of $40 per day, including fuel and operator. This expenditure of $400 would have reduced the $1,070 estimated excavating cost to $670, allowing $270 for cleaning up the trench after the machine and excavating the car track and road crossing. A further saving of $12 on insurance and $77 in foreman's wages by shortening the time from five to three weeks would have been effected. This total saving of $499 would have turned the $398.86 loss into a profit of $100.04, or 3.2 per cent.

Cost Data.—The cost of the work was as follows:

Labor:		
Laborers, 278 men-days, at $4 (10-hour day)	$1,712.00	
Night watchman, 4 nights, at $4	16.00	
Foreman, 34, at $7 a day	238.00	
Bricklayer (union), 7¾x8 hours, at $1.62½	102.00	
Formsetters, 7x9 hours, at $1	63.00	
Total labor	$2,131.00	
Equipment Hire:		
Trucks (1½-ton), 18x10 hours, at $1.25	$ 225.00	
Tractor grader, 4 hours, at $2	8.00	
Air compressor and paving breaker, 3 hours, at $5	15.00	
Concrete mixer, 1 bag, 1½ days, at $6	9.00	
2½-in. diaphragm hand pump	10.00	
2-in. centrifugal pump, 5 days, at $1 per day rental	5.00	
Total equipment hire	$ 272.00	
Material:		
174 sacks cement, at $3 a bbl. del. (in paper)	$ 130.50	
6 sacks Lumnite cement, at $2 for 3-in. street crossing base	12.00	
6,000 common bricks, at $25 per M	150.00	
6 manhole frames and covers, at $26 (Lobdell Foundry, Wilmington)	154.00	
11 yd.—15 tons concrete sand, at $1.40 ton, not including hauling by contractor's truck	22.40	
7 yd.—10 tons plaster's sand, at $1.50 ton, not including hauling by contractor's truck	15.00	
6 yd. cinders, at $0.50 (not including hauling done by trucks charged under labor)	3.00	
1 ton Amiesite, 10 yd. sq. 2 in. thick in place, at $1.70	17.00	
Gasoline and oil for pumps	2.40	
Form lumber, 1x6 and 2x4, 1,800 B. M. at $36	54.00	
24 yd. gravel (1-in.), at $1.75 per ton, 2,600 lb.—1 yd. (20 yd. for wall, 2 yd. for street crossing base, 2 yd. M. H. bottoms)	54.60	
8½ yd. used paving brick and brickbats (hauling charged under labor)	N. C.	
2 two-ton truckloads of old lumber, including 3x12-in. used in 6-ft. lengths for placing every 25 ft. across trench and nailing stakes to	N. C.	
6 individual "tin" pipe forms for manhole inverts in place	18.00	
Total material	$ 647.90	
Summary:		
Contract cost of job		$2,590.00
Extras, manhole $75, 10-in. pipe instead of 8-in.—100 ft. and 5 extra wyes at $0.63 (all fittings cost double price of pipe)		93.90
Equipment hire	272.00	
Labor	2,131.00	
Material	647.90	
Insurance—workmen's compensation, 1½ per cent payroll	31.96	
Loss		398.96
Total	$3,082.86	$3,082.86

The Construction of the Distribution System

Useful information based on the methods and practices at Council Bluffs, Ia., was given in *Municipal News and Water Works* by C. L. Ehrhart, Superintendent Water Works, Council Bluffs, Ia.

It will be assumed that the design of the proposed project is according to good practice and that the materials have been ordered. Therefore the first operation that confronts us is the handling of the pipe from the car.

Handling the Pipe.—Under no circumstances should pipe be allowed to drop or swing against anything that will cause it to crack. It should be handled by means of skids, or better yet, by derricks or cranes which can swing it clear of all obstacles and deposit it without undue jar wherever required. For use in handling small pipe, the writer has found the best method to be by means of a derrick having a 10-ft. boom and mounted on a heavy truck. This derrick is of a type generally advertised, and is inexpensive to buy and can be used for handling many other things than pipe. Such a derrick can even be mounted on the side of a freight car, if it is not convenient to mount it on a truck, and then taken down after the car is unloaded. As soon as the pipe is lifted from the pile, it should be sounded for defects, then swung around and lowered. It is not always possible to lower the pipe directly to stock piles, but several lengths can be laid crosswise on the truck back of the derrick and taken over to the stock pile and put in place quickly. Probably the handiest and neatest stock pile is one in which the pile alternates in the placing of the bell and spigot ends with each layer turned 90 degrees in direction. Such a pile is not liable to slip causing breakage or accident and is handier to check. Many times the pile can be loaded directly to the trucks or trailers and taken to the point where it is to be laid. In the case of large pipe it is often economical to have some company equipped with large stationary booms do the handling. In Council Bluffs we are fortunate in having a bridge company which will unload large pipe to our trucks and trailers at $5.00 per car.

Delivering Pipe to Job.—We have found it most economical to deliver pipe to the job by a truck pulling a trailer where possible. Trailers are rather inexpensive affairs, and we believe no water department should be without one or more. We have been able to haul from 4 to 5 tons on a single trailer in addition to the pipe on the truck. In removing pipe from the truck or trailer to the ground, care should be taken that there is no chance of breakage. On dirt streets it is possible to slide the pipe off the end without damage, but on paved streets such a practice cannot be carried out. We have found it best to lower pipe on paved streets with the above mentioned derrick mounted on a truck. As this truck is also used in lowering the pipe into the trench, it is not necessary to string the pipe with the bell ends one way, for it is a small matter to swing a pipe around when suspended from the boom. We have also had occasions when it was not advisable to string the pipe at all, but to pile it on the parking at convenient locations. In this way it can be stored longer without complaint from the public and without the danger encountered by stringing the pipe in the street. As the pipe has to be picked up by the truck for placing in the trench, the short run necessary to take it from the pile to the trench does not noticeably hold up the work as would be the case of handling by hand.

Digging the Trench.—With the material on the ground, the next operation is making the excavation. Some of the larger cities are fortunate enough to have trenching machines, but in the smaller or medium sized cities, we believe most of this work is done by hand. In either case the trench should be dug wide enough to allow the back filling material to slip past the pipe and fill the lower quarters below the pipe. If a ditch is cramped for width, the back filling material is likely to rest upon the top of the pipe, causing an undue strain and possible breakage. If the trench is wide enough to allow proper back filling, it is also wide enough to work in comfortably. In the northern part of the United States the depth of the trench is generally regulated by the frost line, the cover being sufficient to insure against freezing. This cover is generally enough to properly cushion the pipe against excessive weight and the consequent strain.

Proper tools should be provided for the excavation work. In cases where it is necessary to go through paving or hard dirt surface, we have found that the cut can best be made with busters or spades operated by compressed air. The compressor is one of the handiest tools the water works man can have, as it takes care of a great many hard jobs which are expensive to handle by hand. While it is better to have a compressor of at least 100 cu. ft. capacity, smaller ones may be purchased and mounted on a truck and driven from the drive shaft. The larger compressors should be purchased mounted, or mounted on the running gear of a second-hand truck and used as a trailer. To avoid undue jar to the compressor, the running gear should have good springs and at least solid tires if pneumatics are not available. All the tools in excavation work should be kept in good condition, and the spades and shovels should be of a light high-grade steel. The best shovels and spades are the cheapest in the long run and are not so tiring to the workmen due to their lightness.

The Trench.—The trench which is to receive the pipe should be graded with a string line the same as for sewer work, making the high and low points come at hydrant locations, if possible. This will insure that the sediment can be blown out at the low points and the air taken out at the high points, preventing the line from becoming air bound. If the walls of the trench being dug are dry and of the right material, no bracing will be necessary. However, sandy or wet material will require bracing in order to make the trench safe and allow the placing of the pipe. Water in the trench should be removed before attempting to place any pipe. Formerly this was taken care of by hand trench pumps, but the gasoline driven units are now so inexpensive that no pipe laying crew is complete without them. Clear water may be removed by motor driven centrifugals to good advantage. In laying out trenches it is a good plan to keep at least 5 ft. away from other parallel trenches, if possible, so avoiding the chance of the ditch on the side near the parallel trench caving in. Such cave-ins generally come without warning and are apt to be serious. Formerly when it was necessary to roll the pipe into the ditch, it was customary to pile all the dirt on one side of the trench. This sometimes created cave-ins because of the excessive weight of the dirt. Where the pipe is handled by derricks or cranes, it is not necessary to keep one side of the trench clear, but it is better to divide the dirt and thus spread the weight on both sides of the ditch. In the past it has generally been customary to dig the bell holes as the pipe was placed in the trench. However, where portable trucks are used it is possible to lay from 10 to 12 lengths per hour, so the bell holes cannot be dug after the pipe is in the ditch without delaying the work. Under such conditions it is better to measure off the bell hole locations and put enough men digging bell holes so as to insure no delay in the pipe laying.

Laying the Pipe.—With the trench ready to receive the pipe, it is important that the laying proceed as fast as possible. With the portable truck derrick the pipe should be raised with the sling around the middle so as to keep it balanced. As soon as it is clear of the ground, the pipe should be given a final sounding to prevent defective or cracked pipe from entering the ditch. The derrick is then run alongside the ditch, the boom swung around and the pipe lowered. In the meantime one man should clean and dry the bell of the last pipe laid very thoroughly, as many defective joints are caused by dirt or foreign matter. When the next pipe is lowered the same man should also clean the spigot end. He should then place a strand of hemp around the pipe and guide it into place when it is sent home. The best hemp to our notion is of the dry braided type, and two strands are usually sufficient. Should the pipe pinch to one side as it is being entered, it is easy to swing it from side to side or raise it with the derrick until the hemp is driven home and spigot end properly centered in the bell.

In cases where it is impossible to use a derrick, the pipe may be lowered into the trench by means of a rope at each end with a roiling hitch, one end of each rope being held under the feet of the men lowering, and the other end paid out as evenly as possible so as to lower the pipe without dropping. In this way two men can lower a length of pipe. For sizes too heavy for lowering by hand, a four legged derrick can be used, or even better, a large crane or drag line.

Making the Joints.—After the spigot end of the pipe is home and yarned, the joint should be prepared immediately for the joint material, as delay may cause foreign matter to enter. We believe it is best to use a square running rope with a clamp to tighten it up. We have also found it best to seal this running rope against leakage by the use of fire clay rather than ordinary clay. Fire clay may be used over and over again and is not expensive in the long run. After the running rope is sealed, a gate should be built up depending upon the materials used for joint purposes. Either lead or lead substitutes require heating, and while formerly the ketties were heated with a wood or coal fire, it is much better to use a kerosene burner, as it will heat the material quickly and once heated will hold it in readiness for use, insuring against delays caused by cold material. The joint material should be handled carefully so as to avoid spilling and the possible injury to workmen. The pouring of the joint should be done continuously, and in case that one pot will not run the joint, additional pots should be in readiness to carry the pouring out with the least break in time. Immediately after the pouring of the lead, it should be caulked to take up the shrinkage caused by cooling. Formerly most of this work was done by hand, the caulker running around the pipe first with a chisel following up with the caulking irons, using the small ones first. However, if compressed air is available, this method should be used in caulking. Compressed air driven joints are better than hand driven, as the lead can be taken up from an eighth to a quarter-inch more than by the hand method without any danger of splitting the bells. Such joints are superior, as the last one driven during the day is as good as the first, whereas the quality of hand caulked joints is liable to lag during the latter part of the day. Furthermore, where the pipe is being laid in large quantities it is absolutely necessary to caulk by air in order to keep up with the laying crew. Sometimes on the larger joints the lead fails to pour evenly, causing a break in the joint, but this may be remedied by caulking lead wool into the spot where the break occurs.

Pouring Wet Joints.—At times unavoidable conditions cause the joints to become wet, and extreme care must be taken in pouring such joints. Before pouring the lead a quantity of coal oil should be poured into the joint, followed immediately by the lead. In place of the coal oil, lubricating oil or candle shavings may be used with equally good results. It is also a good plan to make a small hole with a knife in the bottom of the joint for drainage purposes. This may allow a little lead to run through, but it will soon freeze at the point of drainage and pour properly. When the pipe is finally placed in the ditch, it should not rest on any solid or unyielding projections, but should lay evenly so that it will not be subject to any strain, as every strain is a potential trouble maker.

Cutting Pipe.—The writer has seen many cases of poor pipe cutting caused by awkward methods. A pipe can be cut fairly even if the work is done right. Before attempting to make a cut the pipe should be marked at the exact distance from the end by means of a tape or rule. It is then possible to place a running rope or even cloth tape around the pipe at this point, after which the whole circumference of the pipe may be marked very easily. A cross mark should be made to show the starting and ending points of each turn of the pipe. The pipe should then be placed on a heavy timber with the cutting line directly over the middle of this timber. Starting at the cross mark a slight cut should be made using a sledge and hardy. When the cross mark is reached the pipe should be rolled back to the point of beginning, after which a second and heavier line may be cut with the hardy. By rolling the pipe back and starting the cross mark each time, the strain will be kept equal. Finally the pipe will become crystallized to the point where it will snap off fairly evenly without projections exceeding a quarter of an inch. In making cuts on larger pipe it is a good idea to make the first round with a diamond point, as this removes a considerable amount of the material. Then by following with the hardy, as above mentioned, pipe will crystallize and crack. Cutting old pipe in the ditch has been more or less difficult, particularly in the large sizes. When the cut was made with regular cutters, the pipe was generally bound in place even after the cut at both ends was complete, making it necessary to break the pipe, which was oftentimes hard to do in the larger sizes. There is on the market at the present time an oxy-acetylene outfit having a special torch for burning castiron pipe, and we have found this to be the handiest method of cutting pipe in the ditch, as the cut is at least a quarter of an inch wide, and the pipe is free as soon as the cuts are made. To secure the best results with such an outfit, the pipe should be drained, as water in the pipe tends to carry away the heat. It is also best to make the first round with the diamond point, as any chalk marks are burnt off by the hot flame, while the track made by the diamond point can be readily seen.

Valves.—Every distribution line should be properly valved. most of us have had occasions when we would have given much to have had valves at the proper locations. These valves should be spaced so that a minimum amount of main is thrown out of service whenever it is necessary to work on the line. Not only is this according to the Underwriters' specifications, but it prevents the needless shutting off of house service. If the Underwriters' rules are followed, the system will always be properly valved. In setting valves a concrete base should be provided so that there is no chance of the valves settling. We have found concrete from old sidewalks to be ideal for this purpose. Every valve must necessarily be provided with a valve box or manhole so that shutoffs may be made quickly. The question of whether to use boxes or manholes is more or less optional in the small sizes, but valves larger than 12 in. should always have the manholes.

Hydrants.—Hydrants should be set at least not farther apart than each street intersection, and in the business district, or in the residence district where the intersecting streets are too far apart, additional hydrants should be set in the middle of the block. At least the business district should be equipped with steamer hydrants, and it is better if the residential districts can also be equipped with the same although the necessity is not so great. In placing hydrants care should be taken that the hydrant is kept far enough back of the curb to clear all automobile bumpers, and it should be set high enough so that the fire department will experience no difficulty in making the hook-up by reason of dirt or snow being too close to the caps. The writer has seen many hydrants set at crazy angles and has made it a point that all hydrants set under his direction were properly plumbed. After plumbing the hydrant should be braced near the top with temporary wood braces to hold it plumb while the back filling material is being tamped in place. The hydrant should have a base of concrete similar to that used for valves, and it is most necessary that the space back of the hydrant to solid ground be filled with concrete to prevent the hydrant from blowing off. No wood should be allowed in these braces, as it will rot and allow the hydrant to push away. At least a bushel or more of brickbats, preferably of soft brick, should be placed around the base of the hydrant to take care of the drainage water. If it is not provided, the hydrant will not drain, with the probability of freezing. The writer has never set a hydrant without an auxiliary valve in front of it. The expense is not great and is justified, as it allows the hydrant to be repaired without interference to service. Hydrant connections should be not less than 6 in. in diameter and the hydrant should preferably be of the same size.

Connecting New Lines.—Connecting new lines at right angles to old lines not provided with tees or crosses, naturally necessitates a tap which may be made in two ways, by means of a machine, or by cutting out a section of the pipe and setting in a tee or cross. When made by machine care should be taken that the split sleeve is centered evenly around the pipe and that there are no defects in the joint. The sleeve should be carefully leveled before the joint is run. After the tee is in place and the joint caulked, the machine should be hooked up and the cutting started. The pilot cut is easily made, but the main cut takes considerable labor, and it is of importance that the cutters be sharp and all ground to an even length, otherwise the cutting will be uneven and exceedingly hard to make. After the cut is made and the piece drawn out, the valve should be closed and the machine removed, after which the laying of the pipe may proceed in the ordinary manner. In cases where it is necessary to insert a tee or cross, a section of the pipe should be taken out, after which the fitting may be set in place and the opening closed by means of a short length of pipe and a sleeve. Where the sleeve is placed a small section of the pipe is generally missing due to the fact that it had to be cut short in order to enter the bell. Should a valve be placed close to this point and the pressure applied to one side of the valve only, there is a possibility of the valve pushing toward this open space and opening up a joint at the valve. This space may be elimi-

nated by cutting a very short section of pipe and dropping it in the opening before the sleeve is set.

Fittings such as tees, elbows and plugs must be properly braced against solid earth in a manner similar to the bracing required for a hydrant. If such bracing is not placed, the chances are that the pressure will open up a joint or crack a pipe near the fitting. Sometimes it is necessary to brace back a considerable distance, and we have found it very convenient to use old pipe between the fitting and solid earth in such cases.

Testing the Pipe Line.—At the completion of each block of pipe, a test should be applied to prove that no defective pipe or joints are in the line. Formerly when central station pressure was carried for fire service, it was necessary to make what you might term a high service test, but since the advent of the fire department pumper, the policy of putting on additional pressure has practically disappeared, so that we feel safe in using domestic pressure for our tests. If possible test plugs should be provided so as to make it convenient for removing the air in the line and also for removing the plug when the test is completed. However, if test plugs are not available, an ordinary plug may be used with a lead joint shallower than normal. In cases where oxy-acetylene outfits are available, these joints may be melted very easily.

Back Filling.—Back filling may be done by machine, by hand back filler and team, or by hand, and the relative cost and speed is in the above order. Naturally a machine back filler is preferable, although the use of a hand filler and team does not cost so very much more. Hand back filling is expensive and should not be practiced, if possible. We have found it best to pile all the dirt over the ditch and after it is filled to flush the ditch. If this flushing is done from above, the results will be poor and incomplete as the dirt will wedge part way down in the trench, and the bottom of the ditch will not be properly settled. The best method of flushing is to place an 8-ft. pipe on the end of the hose and push this pipe into the ditch until it hits the water main. Then allow the water to flow until it shows up at the top of the ditch, after which the pipe may be moved forward about ten feet. This method is more efficient and better than hand tamping. We have taken a hand tamped ditch and applied the flushing in this manner and caused the dirt to settle several inches. Practically all the dirt that has been thrown out, except that displaced by the pipe, can be replaced in this manner.

Checking Costs.—The cost of laying a water main should be checked from day to day in order that everybody concerned is fully conversant with the results. The foreman on the job can practically make or break as regards costs. If he is in sympathy with the idea of economy and efficiency, and uses his head in planning his work and arranging his men, he can get good results at moderate costs.

Records.—With the job complete, a record should be made showing the length, depth, location of specials, hydrants, valves and any other data that might be of value in the future. This record should be placed on a map and filed away in a fireproof vault or safe. Card indexes should be made in duplicate showing location of all valves and hydrants, one set being kept in a fireproof place, and the other set kept convenient for instant inspection. Unless this is done, the project cannot be called complete.

Charging Water Works Construction Equipment

The following notes from *Water Works* show the practice of the Water Department of three cities in handling charges for their construction equipment:

New Bedford Charges Equipment to the Job.—We have two trenchers, a steam shovel, air compressors and a steam derrick. Any minor repairs that take place through the ordinary running are usually charged to the particular job on which the machine is working. For example, we bought this machine for an extension in laying a 40-in. pipe, and repairs were charged to that job. It has been working recently in some ditching work in connection with draining some of the swampy territory around the ponds. While that work is going on it is charged to that job, that is the ordinary small repairs. On any serious repairs, these equipments would be charged to account of tools, which account is included in our mains extension account.

We have no back fillers and air compressors are charged on our tools account, because that is going from one short job to another. Our trenching machines, of course, are not used on short jobs. The repairs are usually charged to jobs on which they are working, when it is finished up or broken down.—Stephen H. Taylor, New Bedford, Mass.

Plan at Youngstown, O.—We have a plan for handling this particular item which I feel is rather complete, in so far as we have a department called "auxiliaries." Auxiliary equipment is one branch of that department or system of accounting. In our auxiliary department expenses we have such operations as machinery, like the shop, garage or automotive equipment and a division under the care and supervision of a general, all-around mechanic, who is manager. This division is called construction equipment. In that department we have our two trenchers, air compressor, back fillers, tractors, trailers, our special pipe handling truck and our truck crane.

We considered for some time where to allocate the cost of maintenance and upkeep and how to distribute it equally among our various departments, which are main construction, maintenance and service construction.

Those three branches use our machinery. We have in addition a building construction division. We do all of our own contracting. Our expense, or rather the life of our machines, is estimated. We try to establish a rate based on the average life of such equipment.

We have an hourly rate for all of our machines, which this auxiliary department calls construction equipment and which we charge into main construction, service or maintenance. We are taking our compressor out on the road and charging $1.50 an hour to that job, which money is actually transferred on the books into our auxiliary equipment department. The $1.50 an hour price must absolutely support that machine. This department keeps its own costs. It has a system of cost and repairs in the operation of this machinery. This money goes back to the department and is placed to the credit of that machine at the end of five years, if it is correct to estimate the life of an air compressor at five years, a trenching machine at five, and a back filler at three. We attempt at the end of those periods to have money enough in those funds to replace the equipment. In that way we have continuously kept up an assortment of equipment, our additions to equipment being out of a surplus which we accumulate.

To determine this rate is quite a problem. We have been doing it now for three years and we found we made too little charge in our estimate. On the other hand, we felt that we should get $2.50 an hour from one of our departments for the operation of our trenching machine, and later found that that was too much. Because of the amount of available time and the low cost of that particular unit over the first two years, we were going to have in our treasury, by the end of a five-year period, enough money to buy three or four more machines.

We revised our rates downward. Every quarter we check up to get the rate per hour. We feel that at the end of those machines' useful lives we will have enough money in the fund to make replacements as well as keep those machines in wonderful condition. The expense of operating them is never charged to any one job. All departments pay the same for equipment and operation. Each department superintendent has to get his order in for construction equipment in his turn so that he will have a machine when he wants it.

We do all of our own construction work, all of our service installation, every bit of our building and small construction jobs, even to the repaving of streets. We have only one timekeeper, an accountant, and he has no trouble at all handling this detail of cost accounting. It really comes from the source on our daily time reports, which are turned in by the head of the department for these men. There is absolutely no excessive overhead or costs in keeping this system. It is convenient and has paid well for its time and trouble.

The problem of picks, shovels and other small tools is rather difficult. We have felt that to equip tool boxes with the ordinary amount of tools for the job, making replacements by charging it to the job itself is a pretty good plan. If the tool is lost on a job, certainly the cost of that replacement, say of a shovel, pick, lantern or whatever it is, should be charged to that particular job. Those things do not all wear out at once, they are being continually replaced so that we can charge such equipment into miscellaneous cost of doing a certain job. Our storekeeper has a job in that. A man cannot requisition a dozen new picks and shovels and get away with it in our department. If he tries such a thing there is some question and we refer his requisition back to his supervisor. That supervisor certainly has more tools laid away in the tool room somewhere which are charged to his department.

We do not let a tool out on a job without a requisition. If a man wants as many as five lanterns he can requisition them from the storeroom. If he wants two dozen it is up to his supervisor or he may provide those from other jobs. We aim at all times to avoid a surplus of tools from the division. Just as many as they need and no more. Of course, they have some from the blacksmith's shop, but we try to charge that to replacement of lost and worn-out tools, not to the job.—M. C. Kinder, Youngstown, O.

How Charges are Handled at Cleveland, O.—We charge a good deal to capital account. We have a great number of trucks and passenger cars. We carry the operation of these machines, trucks and so forth on the books against the maintenance and operation account. The operation is separate from the maintenance, and on our large construction jobs, a certain rate, depending on the size of the truck, is charged against that particular job as rental. On the smaller jobs in that connection we charge it to the consumer. We have smaller trucks with a rental charge per hour against that particular job, so that the rental charge we get on all the trucks will very nearly offset the maintenance and operation of these trucks. On the passenger cars, of course, we do not attempt to allocate any of the expense to the job itself, as supervision is charged as a maintenance or operation item of automobiles. We have a certain amount each year, based on our previous expense, as to what our budget must cover the following year, so we get into the job on trucking a fair charge for the use of machines.

The man in charge of the trucking division does no work with any trucks unless he gets a requisition from the department wishing to use that truck. Of course, if there is a pick-up job or a half dozen pick-up jobs, about all one can do is charge an estimated amount, including the time going to the station, picking up things from two or three different plants, and allocate that time and charge on the requisition. But that does not apply as much to the construction end as to the operation of small pick-up jobs.

All of our machines are classified. There has been a division started to take care of and find the actual cost for operation and maintenance of each machine. Numbers are put on each truck and on the passenger cars, instead of putting on speedometers, and a daily record of the gas and oil and everything that goes into the particular truck or passenger car is kept, so that within probably a year's time we shall have valuable data as to what the operation and maintenance of those cars are.—Mr. King, Cleveland, O.

Frost Penetration in City Streets

From an Article in Water Works, July, 1926, by Scotland G. Highland, General Manager, Clarksburg Water Board, Clarksburg, W. Va.

Frost Penetration and Depth to Which Mains and Services Are Laid in City Streets

Name of State or Province and City	Lowest Depth of Frost Penetration in City Streets During the 25 Years, Ending March, 1926	Dept to Which Mains and Services Are Laid in City Streets (1926)
Alberta, Can.		
Calgary	12 ft.	8 ft. in loam, 10 ft. in gravel.
Edmonton	6½ ft.	8½ ft. trench for mains; 7 ft. trench for services.
Saskatchewan, Can.		
Moose Jaw	9 ft.	9 ft. cover.
Regina	.....	7½ ft. cover.
Ontario, Can.		
Brantford	.....	5½ ft. cover.
Chatham	3 ft.	4 ft. cover.
Ottawa	6 ft.	6½ ft. cover.
Windsor	.....	5 ft. cover.
Quebec, Can.		
Montreal	5 ft.	6 ft. trench.
Manitoba, Can.		
Winnipeg	7 ft.	7½ ft. cover.
Little Rock, Ark	.....	2½ ft. trench.
Sacramento, Cal	.....	2 ft. cover.
Colorado.		
Leadville	9 ft.	7 ft. cover.
Denver	.....	4½ ft. cover.
Colorado Springs	.....	4½ ft. cover.
Connecticut.		
Hartford	6 ft.	4 ft. cover.
Meridian	.....	4 ft. cover.
Wilmington, Del	.....	3 ft. 8 in. cover.
Tallahassee, Fla	.....	3 ft. trench.
Atlanta, Ga	.....	Mains 2½ ft. cover; services 2 ft. cover.
Boise, Idaho	.....	4 ft. cover.
Illinois.		
Danville	4 ft.	5 ft. trench.
Quincy	3 ft.	Mains, 4½ ft. cover; services 3½ ft. cover.
Chicago	.....	5½ ft. cover.
Bloomington	.....	3½ ft. to 5 ft. trench.
Indiana.		
Richmond	5 ft.	Mains 5 ft. cover; services 4½ ft. cover.
Logansport	6 ft.	Mains 5 ft. cover; services 3½ ft. cover.
Gary	5 ft.	5½ ft. cover.
Terre Haute	5 ft. 7 in.	4½ ft. cover.
Fort Wayne	.....	5½ ft. trench.
Elkhart	.....	5 ft. cover.
Lafayette	.....	4½ ft. cover.
Iowa.		
Fort Dodge	7 ft.	5½ ft. cover.
Dubuque	6 ft.	6 ft. cover.
Des Moines	5½ ft.	6 ft. trench.
Council Bluffs	5 ft.	5 ft. cover.
Burlington	5 ft.	5 ft. cover.
Davenport	.....	6 ft. cover.
Cedar Rapids	.....	5½ ft. cover.
Kansas City, Kans	.....	4 ft. cover.
Kentucky		
Louisville	.....	3 to 3½ ft. cover.
Frankfort	.....	3 ft. cover.
Baton Rouge, La	.....	2½ ft. cover.
Maine.		
Portland	5 ft.	5 ft. cover.
Biddleford	.....	5½ ft. cover.
Augusta	.....	5 to 5½ ft. cover
Maryland		
Haggerstown	2 ft. 8 in.	3 ft. cover.
Baltimore	.....	Mains 3½ ft. to 4 ft. cover; services 3½ ft. cover.
Massachusetts.		
North Attleboro	7 ft.	6 ft. cover.
Fitchburg	7 ft.	6 to 7 ft. trench.
Springfield	5 ft. 10 in.	6 ft. cover.
Melrose	.....	5 to 5½ ft. cover.
Haverhill	.....	5 ft. cover.
Lynn	.....	5 ft. cover.
Brocton	.....	5 ft. cover.
Fall River	.....	5 ft. cover.
Beverly	.....	Mains 4½ ft.; services 5 ft., 4½ ft. cover.
Holyoke	.....	4½ ft. cover.
Gloucester	.....	4 to 5 ft. cover.
Lowell	.....	Mains 5 ft. cover; services 5½ ft. cover.
Michigan.		
Battle Creek	6 ft.	5 ft. cover.
Flint	5 ft.	Mains 5 to 6 ft. cover; services 5 ft. cover.
Detroit	5½ ft.	8 ft. trench.
Minnesota.		
St. Paul	11 ft.	Mains 6½ to 7½ ft. cover; services 7½ ft. cover.
Duluth	9 ft.	Mains 8 ft. to Axis of pipe; services 9 ft. cover.
Minneapolis	.....	2 ft. cover.
Jackson Miss	6 ins.	4 ft. cover.
Kansas City, Mo	2½ ft.	Mains 3½ ft. to 12 ft.; services 5 ft.
Montana.		
Great Falls	.....	6½ ft. cover.
Butte	.....	5½ ft. cover.
Helena	.....	5½ ft. cover.
Omaha, Nebraska	.....	4½ ft. cover.
New Jersey		
Patterson	3½ ft.	4½ ft. cover.
Jersey City	.....	4 ft. cover.
Trenton	.....	3½ ft. cover.
Elizabeth	.....	3½ ft. cover.
Camden	.....	3 ft. cover.
Sante Fe, N. M	3 ft.	5 ft. cover.
New York.		
Buffalo	6 ft.	5½ ft. trench.
Elmira	4½ ft.	4½ ft. cover.
Syracuse	4 ft.	4 ft. cover.
New York City	2½ ft.	Mains 6 ft. trench; services 5½ ft. trench.
Ogdensburg	.....	5 ft. cover.
Albany	.....	5 to 6 ft. cover.
Glen Falls	.....	4½ to 6 ft. cover.
Gloversville	.....	4½ ft. cover.
Rochester	.....	Mains 2½ ft. trench; services 2 ft. trench.
Raleigh, N. C	1 ft. 3 in.	7 ft. cover.
Bismark, N. D	.....	5 ft. cover.
Ohio.		
Akron	6 ft.	4 ft. cover.
Toledo	4½ ft.	3½ ft. cover.
Cincinnati	3 ft.	6 ft. cover.
Cleveland	.....	Mains 4 ft. cover; services 3½ ft. cover.
Lima	.....	3½ ft. cover.
Columbus	.....	Mains 5½ ft. cover; services 5 ft. cover.
Pennsylvania.		
Hazelton	7½ ft.	6 ft. cover.
Erie	.....	Mains 4½ ft. cover; services 3½ ft. cover.
Altoona	.....	4 ft. cover.
Pittsburgh	.....	4 ft. cover.
Allentown	.....	3½ ft. cover.
Chester	.....	3 ft. cover.
Harrisburg	.....	3 ft. cover.
Johnstown	.....	3 ft cover.
York	.....	6 ft. cover.
Rhode Island.		
Woonsocket	7 ft.	6 ft. cover.
Providence	.....	Mains 4 ft. 8 in. to center of pipe; services 4 ft. 6 in.
Salt Lake City, Utah	3 ft.	4 ft. cover.
Montpelier, Vt	.....	5½ ft. cover.
Richmond, Va	.....	Mains 4 ft. cover; services 2½ ft. cover.
Washington.		
Spokane	5½ ft.	4½ ft. cover.
Everett	1½ ft.	2½ ft. cover.
Seattle	.....	Mains 4 ft.; services 2 ft.
West Virginia.		
Wellsburg	.....	4½ ft. cover.
Wheeling	3 ft.	3 ft. cover.
Clarksburg	3 ft.	4 ft. cover.
Bluefield	2½ ft.	4 ft. cover for mains; services 2½ ft. cover.
Parkersburg	.....	3 to 6 ft. cover.
Charleston	.....	3 ft. cover.
New Martinsville	.....	3 ft. cover.
Wisconsin.		
Madison	6½ ft.	6 ft. cover.
Fon du Lac	.....	Mains 6 to 7 ft. cover; services 5½ to 6½ ft. cover.
Milwaukee	.....	6 ft. cover.
Kenosha	.....	5½ ft. cover.
Cheyenne, Wyo	.....	5 ft. cover.

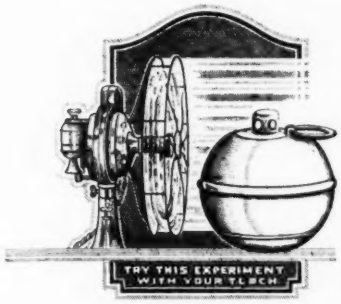
McCLOSKEY TORCH COMPANY

337 20th Street, Toledo, Ohio

Manufacturers of Bomb Shell Torches

Products: BOMB SHELL TORCHES.

McCloskey Bomb Shell Torches are positively the best danger signal made. They are *unbreakable, leak-proof, efficient, reliable, safe.*



Are equipped with Cyclone burner and wick ready for instant use. Our cyclone burner which affords greater protection under all weather conditions also effects a great saving in fuel and wicks. Torches now being used without Cyclone burners can be equipped with this wonderful burner by means of our adapter, shown below, making any torch now in use interchangeable. On gross-lot orders we equip our torches with a brass nameplate, marked "Property of, etc.," free of charge. On smaller orders they will be furnished at cost.

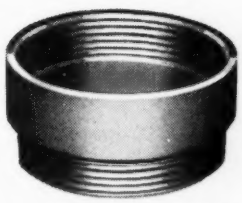
McCloskey Bomb Shell Torches are being used everywhere by State and County Highway Departments, Railway, Gas and Telephone Companies and by all progressive contractors and are being exported to all parts of the world.

McCloskey Torches will burn from Saturday night until Monday morning with just one filling. No barricading is necessary.

McCloskey Bomb Shell Torches are made in two halves, of rolled and pickled deep drawn steel and welded together. Cast iron counterweight pressed in bottom absolutely prevents them from being knocked over. They are never stolen—being suitable for construction work only. Are enthusiastically endorsed by insurance and bonding companies as they have reduced accident claims nearly 100 per cent because they remain lighted through the hardest wind and rain storms. The No. 1 size, which is of 4 quart capacity, is made of U. S. Standard 13 gauge steel. The No. 2 size, which is of 3 quart capacity, is made of U. S. Standard 15 gauge steel.

If your dealer does not handle torches write us, and we will supply you direct, as you cannot afford to be without this modern protection.

Cyclone Burner



Adapter for Earlier Models

Wick Holder

KALAMAZOO FOUNDRY & MACHINE COMPANY

580 East Main Street, Kalamazoo, Mich.

Kalamazoo Trenching Braces

Products: KALAMAZOO TRENCHING BRACES WITH FORGED STEEL SCREWS.

New List Subject to Discount
Barrels of Heavy Steel Pipe

NOTE:

Our Pipe Barrels are Heavy Steel Pipe that will stand the necessary rough use and NOT SPLIT

Style H Wrench FREE with every 2 dozen Style H G

Regular Trench Brace

1½ inch Heavy Steel Pipe Barrels
1¼ inch Steel Screw

Telegraph Code	Length When Closed	Extend Safely	Per Dozen	Weight Per Doz.
Hack	1 ft. 3 in.	7 in.	$24.88	130 lbs.
Habit	1 ft. 6 in.	10 in.	26.41	147 lbs.
Haft	1 ft. 9 in.	10 in.	27.80	157 lbs.
Hale	2 ft.	10 in.	29.18	161 lbs.
Hank	2 ft. 6 in.	10 in.	31.91	174 lbs.
Harp	3 ft.	10 in.	34.65	197 lbs.
Haul	3 ft. 6 in.	10 in.	37.40	215 lbs.
Hate	4 ft.	10 in.	40.15	232 lbs.
Guard	For Mud Guard add		6.00	39 lbs.

Regular Heavy Trench Brace

2 inch Heavy Steel Pipe Barrels
1½ inch Steel Screw Threaded 15 inches
Extend Safely 13 inches

Telegraph Code	Length When Closed	Price Per Doz.	Weight Per Doz.
Hepe	3 ft.	$43.61	296 lbs.
Hemp	3 ft. 6 in.	46.13	314 lbs.
Help	4 ft.	48.62	334 lbs.
Heke	4 ft. 6 in.	50.70	353 lbs.
Hear	5 ft.	53.73	374 lbs.
Hebe	5 ft. 6 in.	56.24	394 lbs.
Heck	6 ft.	58.76	413 lbs.
Hede	6 ft. 6 in.	61.24	432 lbs.
Guard	For Mud Guard add	12.00	80 lbs.

Ball and Socket Brace

1½ inch Heavy Steel Pipe Barrels
1¼ inch Steel Screw

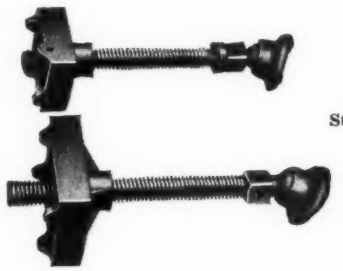
Telegraph Code	Nominal Length	Actual Length Closed	Extend Safely	Price Per Doz.	Weight Per Doz.
Sabe	1 ft. 3 in.	1 ft. 4¾ in.	7 in.	$31.24	161 lbs.
Sace	1 ft. 6 in.	1 ft. 7¾ in.	10 in.	32.64	178 lbs.
Sade	1 ft. 9 in.	1 ft. 10¾ in.	10 in.	33.94	185 lbs.
Safe	2 ft.	2 ft. 1¾ in.	10 in.	35.25	192 lbs.
Sage	2 ft. 6 in.	2 ft. 7¾ in.	10 in.	37.87	210 lbs.
Sahe	3 ft.	3 ft. 1¾ in.	10 in.	40.47	226 lbs.
Saje	3 ft. 6 in.	3 ft. 7¾ in.	10 in.	43.07	245 lbs.
Sake	4 ft.	4 ft. 1¾ in.	10 in.	45.69	264 lbs.
Guard	For Mud Guard add			6.00	39 lbs.

Style S Wrench FREE with every 2 dozen Style S G

Ball and Socket Heavy Brace

2 inch Heavy Steel Pipe Barrels
1½ inch Steel Screw Threaded 14 inches
Extend Safely 12 inches

Telegraph Code	Nominal Length	Actual Length Closed	Price Per Doz.	Weight Per Doz.
Sepe	3 ft.	3 ft. 2¼ in.	$52.07	323 lbs.
Seme	3 ft. 6 in.	3 ft. 8¼ in.	54.57	343 lbs.
Sele	4 ft.	4 ft. 2¼ in.	57.08	364 lbs.
Seke	4 ft. 6 in.	4 ft. 8¼ in.	59.57	385 lbs.
Sebe	5 ft.	5 ft. 2¼ in.	62.08	405 lbs.
Sece	5 ft. 6 in.	5 ft. 8¼ in.	64.57	425 lbs.
Sede	6 ft.	6 ft. 2¼ in.	67.08	444 lbs.
Sefe	6 ft. 6in.	6 ft. 8¼ in.	69.59	464 lbs.
Guard	For Mud Guard add		12.00	80 lbs.



Style T

Kalamazoo Timber Brace Fittings

Telegraph Code	Screw Inches	Timber	Extend Safely	Price Per. Doz. Plain Swivel	Weight Per Doz.
Plow	1¼	4x 4	10 in.	$24.80	142 lbs.
				Ball and Socket	
Thaw	1¼	4x 4	10 in.	30.05	173 lbs.
Time	1½	4x 4	12 in.	40.91	215 lbs.
Tiger	1½	6x 6	12 in.	47.83	300 lbs.
Trust	1¾	6x 6	12 in.	59.13	375 lbs.
Truth	1¾	8x 8	12 in.	66.37	430 lbs.
Trod	1¾	8x10	12 in.	69.58	460 lbs.

Style T Braces are suitable for use in any width trench except the narrowest. They are especially useful in wide excavations. Making the screws, as we do, of stiff steel, and bracing the caps as in our larger sizes, makes these Braces most desirable for heavy and severe service. Cutting thread in cap makes these so that they may be safely extended within two inches of length of thread on screw.

WEMLINGER, INC.

Steel Sheet Piling Specialists

Main Office: 149 Broadway, New York

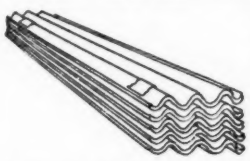
BRANCHES

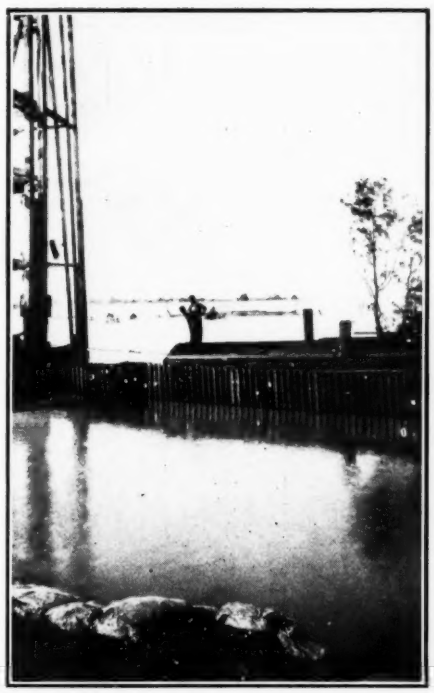
Richmond, 204 N. Jefferson St. Boston, 31 State St. Chicago, 228 N. LaSalle St.

Products: STEEL SHEET PILING. CORRUGATED, ROLLED.

Nearly a quarter-century of specialized experience in this line. Expert advice and prompt service.

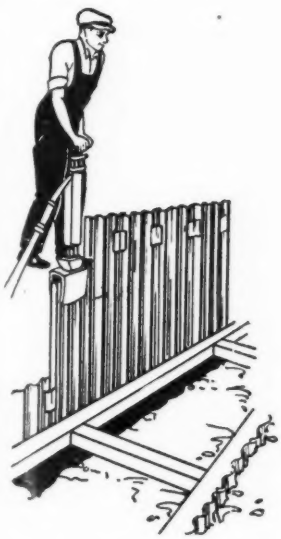
When an excavation is made in wet soil and must be kept free from water, it is highly advisable to use Wemlinger Corrugated Steel Sheet Piling rather than wooden sheeting. The corrugated steel sheets overlap and fit together closely, producing a tight interlock. Yet the short locking clip makes installation comparatively easy. Contractors who have used Wemlinger Sheeting for cofferdams or other wet excavation express complete satisfaction with it.





Space: In storage, or in transit from one job to another, Wemlinger Corrugated Steel Sheet Piling is economical of space. When piled up, the corrugated sections fit each other.

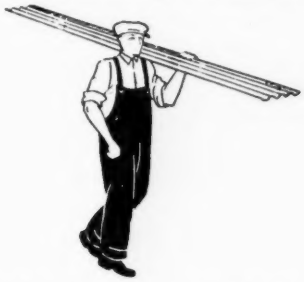
Re-Use: "We must have used our Corrugated sheeting at least 100 times," writes one contractor. While Wemlinger Corrugated Steel Sheet Piling may be used for permanent installations, its temporary use is an important economy because of the great number of times it can be driven and pulled.



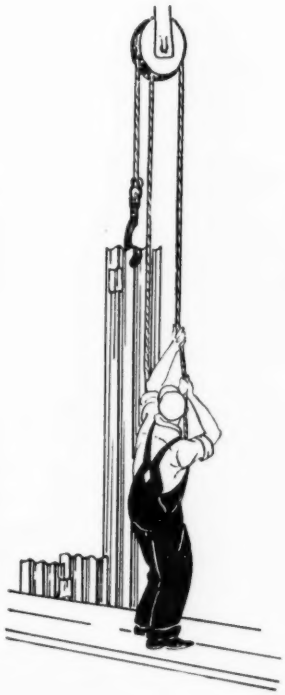
For Certain Kinds of Excavation: If your business involves the use of sheet piling, Wemlinger Corrugated sheeting should be a part of your permanent equipment. In any case it will pay you to write for information. If possible, please state the nature of the work you have to do.

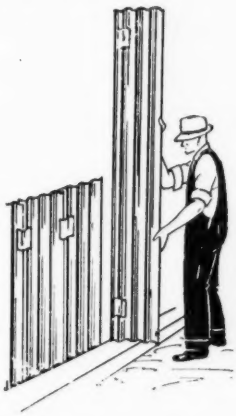
Driving and Pulling: Although Wemlinger Corrugated Sheeting is light, it is also tough and with proper care can be driven by hand, air or steam without damage. In fact, it is often driven and pulled without special equipment. Because of the short interlocking clips the sections are not frozen together by hardened soil. This saves needless expense in pulling.

Labor: Wemlinger Corrugated sheeting is light and easily handled. The short clips, whereby the sections are made interlocking, permit sidewise, interlock. The saving in labor is important.



Standard Makes: Besides Corrugated Sheeting we supply rolled steel sheet piling in all sizes and quantity.





Guarantee: If used, Steel Piling is furnished by us, the same is inspected at time of loading by one of our representatives; we guarantee the same to be in first class condition.

Rented: By the month for temporary installations.

Leased: At fixed price for duration of job.

Sold and Purchased: Any quantity, anywhere.

Tables for Friction of Water in Pipes

LOSS OF HEAD IN FEET DUE TO FRICTION PER 100 FEET OF 15-YEAR-OLD SMOOTH CAST IRON PIPE

From Standard of Hydraulic Society

Gal. per Min.	⅛ Inch Pipe		¼ Inch Pipe		⅜ Inch Pipe		½ Inch Pipe		¾ Inch Pipe		1 Inch Pipe		1¼ Inch Pipe		1½ Inch Pipe		2 Inch Pipe		2½ Inch Pipe		3 Inch Pipe	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
1	5.60	121	3.08	28	1.67	6.4	1.05	2.1														
2			6.16	103	3.35	23.3	2.10	7.4	1.20	1.9												
3					5.02	49.0	3.16	15.8	1.80	4.1	1.12	1.26										
4					5.76	84.0	4.21	27.0	2.41	7.0	1.49	2.14	0.86	0.57	0.63	0.26						
5					7.20	126.0	5.26	41.0	3.01	10.5	1.86	3.25	1.07	0.84	0.79	0.40						
10							10.52	147.0	6.02	38.0	3.72	11.7	2.14	3.05	1.57	1.43	1.02	0.50	0.65	0.17	0.45	0.07
15									9.02	80.0	5.60	25.0	3.2	6.50	2.36	3.0	1.53	1.08	0.98	0.36	0.68	0.15
20									12.03	136.0	7.44	42.0	4.29	11.1	3.15	5.2	2.04	1.82	1.31	0.61	0.91	0.25
25											9.30	64.0	5.36	16.6	3.94	7.8	2.55	2.73	1.63	0.92	1.13	0.38
30											11.15	89.0	6.43	23.5	4.72	11.0	3.06	3.84	1.96	1.29	1.36	0.54
35											13.02	119.0	7.51	31.2	5.51	14.7	3.57	5.1	2.29	1.72	1.59	0.71
40											14.88	152.0	8.58	40.0	6.3	18.8	4.08	6.6	2.61	2.20	1.82	0.91
45													9.65	50	7.08	23.2	4.60	8.2	2.94	2.80	2.05	1.15
50													10.72	60	7.87	28.4	5.11	9.9	3.27	3.32	2.27	1.38
70													15.01	113	11.02	53.0	7.15	18.4	4.58	6.21	3.18	2.57
75															11.80	60.0	7.66	20.9	5.01	7.1	3.4	3.05
100															15.74	102	10.21	35.8	6.54	12.0	4.54	4.96
120															18.89	143	12.25	50.0	7.84	16.8	5.45	7.0
125																	12.75	54	8.16	18.2	5.67	7.6
150																	15.32	76.0	9.80	25.5	6.8	10.5
175																	17.85	102	11.3	33.8	7.94	14.0
200																	20.4	129	13.07	43.1	9.08	17.8
225																			14.71	54.3	10.2	22.3
250																			16.3	66	11.32	27.2
270																					12.25	31.3
275																					12.50	32.5
300																					13.62	38.0

Vel. = Velocity ft. per second. Fric. = Friction Head in Feet.

LOSS OF HEAD IN FEET DUE TO FRICTION, PER 100 FEET OF 15-YEAR-OLD ORDINARY CAST IRON PIPE

Gals. per Min.	24 Inch Pipe		30 Inch Pipe		36 Inch Pipe		42 Inch Pipe		Gals. per Min.	24 Inch Pipe		30 Inch Pipe		36 Inch Pipe		42 Inch Pipe		48 Inch Pipe	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.		Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
									13000	9.22	1.63	5.91	0.54	4.10	0.22	3.00	0.10		
									13500	9.60	1.75	6.13	0.58	4.27	0.24	3.12	0.11		
									14000	9.95	1.87	6.36	0.63	4.43	0.26	3.23	0.12		
									14500	10.3	2.00	6.61	0.68	4.59	0.27	3.35	0.13	2.57	0.06
									15000	10.63	2.12	6.81	0.72	4.76	0.29	3.47	0.14	2.66	0.07
2000	1.42	0.05																	
2500	1.77	0.07							16000	11.38	2.40	7.36	0.83	5.05	0.33	3.71	0.15	2.87	0.08
3000	2.13	0.10							17000	12.09	2.70	7.73	0.91	5.36	0.37	3.94	0.17	3.02	0.09
									18000	12.76	2.97	8.18	1.00	5.67	0.41	4.16	0.19	3.19	0.10
3500	2.49	0.14	1.56	0.04					19000	13.50	3.26	8.66	1.11	6.00	0.45	4.40	0.21	3.37	0.11
4000	2.85	0.18	1.81	0.06					20000	14.20	3.60	9.09	1.22	6.30	0.50	4.63	0.23	3.54	0.12
4500	3.20	0.22	2.04	0.08															
5000	3.54	0.27	2.26	0.09					21000	14.90	3.96	9.54	1.34	6.62	0.55	4.85	0.26	3.71	0.13
5500	3.90	0.33	2.50	0.11					22000			10.0	1.47	6.93	0.60	5.10	0.28	3.90	0.14
									23000			10.45	1.59	7.24	0.65	5.32	0.30	4.07	0.15
6000	4.25	0.38	2.72	0.13	1.90	0.05			24000			10.90	1.71	7.54	0.70	5.55	0.32	4.26	0.17
6500	4.61	0.45	2.95	0.15	2.05	0.06			25000			11.35	1.85	7.88	0.76	5.79	0.35	4.43	0.18
7000	4.97	0.52	3.18	0.17	2.21	0.07													
7500	5.32	0.59	3.42	0.20	2.37	0.08			26000			11.80	1.97	8.20	0.82	6.03	0.38	4.61	0.20
8000	5.68	0.66	3.63	0.22	2.53	0.09			27000			12.26	2.12	8.53	0.87	6.28	0.41	4.78	0.21
									28000			12.73	2.28	8.85	0.94	6.51	0.44	4.96	0.23
8500	6.03	0.74	3.86	0.25	2.69	0.10			29000					9.17	1.00	6.71	0.47	5.14	0.24
9000	6.35	0.81	4.08	0.27	2.84	0.11			30000					9.45	1.05	6.96	0.50	5.33	0.26
9500	6.74	0.91	4.31	0.30	3.00	0.12													
10000	7.07	0.98	4.54	0.33	3.14	0.13	2.31	0.06	32000					10.10	1.19	7.42	0.56	5.67	0.29
10500	7.45	1.10	4.76	0.37	3.26	0.14	2.43	0.06	34000					10.75	1.33	7.88	0.63	6.03	0.33
									36000					11.38	1.49	8.32	0.70	6.39	0.37
11000	7.80	1.20	5.00	0.40	3.46	0.16	2.55	0.07	38000					12.00	1.65	8.80	0.77	6.75	0.40
11500	8.16	1.29	5.21	0.43	3.62	0.18	2.65	0.08	40000					12.62	1.81	9.28	0.85	7.11	0.44
12000	8.50	1.40	5.44	0.47	3.77	0.19	2.77	0.09											
12500	8.86	1.52	5.67	0.51	3.94	0.21	2.89	0.09	42000					13.25	1.99	9.75	0.93	7.45	0.49

Vel. = Velocity ft. per second. Fric. = Friction Head in Feet.

FRICTION OF WATER IN 90° ELBOWS AND EQUIVALENT NUMBER OF FEET STRAIGHT PIPE

Size of Elbow, Inches	24	30	36	42	48
Friction Equivalent Feet Straight Pipe	80	100	120	140	160

Size of Elbow, Inches	⅛	¼	⅜
Friction Equivalent Feet Straight Pipe	2	3	4

Tables for Friction of Water in Pipes

LOSS OF HEAD IN FEET DUE TO FRICTION, PER 100 FEET OF 15-YEAR-OLD ORDINARY CAST IRON PIPE

From Standard of Hydraulic Society

Gal. per Min.	4 Inch Pipe		5 Inch Pipe		6 Inch Pipe		8 Inch Pipe		10 Inch Pipe		12 Inch Pipe		14 Inch Pipe		15 Inch Pipe		16 Inch Pipe		20 Inch Pipe	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
40	1.02	0.22																		
45	1.17	0.28																		
50	1.28	0.34																		
70	1.79	0.63	1.14	0.21																
75	1.92	0.73	1.22	0.24																
100	2.55	1.22	1.63	0.41	1.14	0.14														
120	3.06	1.71	1.96	0.58	1.42	0.25														
125	3.19	1.86	2.04	0.64	1.48	0.28														
150	3.84	2.55	2.45	0.88	1.71	0.32														
175	4.45	3.44	2.86	1.18	2.00	0.48														
200	5.11	4.40	3.27	1.48	2.28	0.62														
225	5.77	5.45	3.67	1.86	2.57	0.74														
250	6.40	6.72	4.08	2.24	2.80	0.92	1.60	0.22												
270	6.90	7.70	4.42	2.60	3.03	1.13	1.70	0.25												
275	7.03	7.99	4.50	2.72	3.06	1.15	1.73	0.27												
300	7.66	9.30	4.90	3.14	3.40	1.29	1.90	0.32												
350	8.90	12.32	5.72	4.19	3.98	1.75	2.20	0.42												
400	10.21	16.00	6.54	5.40	4.54	2.21	2.60	0.54												
450	11.50	19.80	7.35	6.70	5.12	2.65	2.92	0.68	1.80	0.21										
470	12.10	22.40	7.70	7.22	5.49	2.90	3.07	0.75	1.92	0.24										
475	12.20	22.96	7.76	7.42	5.55	2.95	3.10	0.76	1.94	0.25										
500	12.77	24.00	8.17	8.12	5.60	3.30	3.20	0.82	2.04	0.28	1.42	0.11								
550	....	....	8.99	9.60	6.16	3.93	3.52	0.97	2.25	0.33	1.57	0.14								
600	....	....	9.80	11.30	6.72	4.70	3.84	1.14	2.46	0.39	1.71	0.15								
650	....	....	10.62	13.20	7.28	5.40	4.16	1.34	2.66	0.46	1.85	0.19	1.37	0.09						
700	....	....	11.44	15.10	7.84	6.20	4.46	1.54	2.86	0.52	2.00	0.22	1.47	0.10						
750	....	....	12.26	17.20	8.50	7.00	4.80	1.74	3.06	0.59	2.13	0.24	1.58	0.11						
800	....	....	....	....	9.08	8.00	5.12	1.97	3.28	0.67	2.27	0.27	1.68	0.13						
850	....	....	....	....	9.58	8.95	5.48	2.28	3.48	0.75	2.41	0.31	1.79	0.14						
900	....	....	....	....	10.30	10.11	5.75	2.46	3.68	0.83	2.56	0.34	1.89	0.16						
950	....	....	....	....	10.72	10.80	6.06	2.87	3.88	0.91	2.70	0.38	2.00	0.18	1.73	0.12				
1000	....	....	....	....	11.32	12.04	6.40	3.02	4.08	1.01	2.84	0.41	2.10	0.19	1.82	0.14				
1050	....	....	....	....	11.90	13.30	6.70	3.21	4.29	1.09	2.98	0.44	2.20	0.22	1.91	0.16				
1100	....	....	....	....	12.50	14.31	7.03	3.51	4.50	1.20	3.13	0.49	2.31	0.23	2.00	0.17				
1150	....	....	....	....	12.95	15.60	7.35	3.84	4.71	1.34	3.27	0.53	2.42	0.25	2.09	0.18				
1200	....	....	....	....	13.52	16.69	7.67	4.15	4.91	1.46	3.41	0.57	2.52	0.26	2.18	0.19				
1250	....	....	....	....	14.10	18.50	8.00	4.45	5.11	1.51	3.55	0.62	2.63	0.29	2.28	0.20	1.99	0.15		
1500	....	....	....	....	....	....	9.60	6.27	6.10	2.09	4.20	0.85	3.15	0.39	2.73	0.28	2.39	0.21		
2000	....	....	....	....	....	....	12.70	10.71	8.10	3.65	5.60	1.43	4.20	0.66	3.64	0.54	3.19	0.39		
2500	....	....	....	....	....	....	....	....	10.10	5.33	7.00	2.28	5.25	1.01	4.55	0.72	3.99	0.56		
3000	....	....	....	....	....	....	....	....	12.10	7.80	8.40	3.15	6.30	1.47	5.46	1.12	4.79	0.80	3.08	0.27
3500	....	....	....	....	....	....	....	....	14.10	10.08	9.80	4.10	7.35	1.81	6.37	1.43	5.59	1.04	3.59	0.35
4000	....	....	....	....	....	....	....	....	....	....	11.35	5.32	8.40	2.47	7.28	1.85	6.38	1.34	4.10	0.45
4200	....	....	....	....	....	....	....	....	....	....	11.93	6.00	8.82	2.80	7.64	2.08	6.72	1.45	4.32	0.50
4500	....	....	....	....	....	....	....	....	....	....	12.78	6.90	9.45	3.22	8.19	2.23	7.20	1.65	4.62	0.56
5000	....	....	....	....	....	....	....	....	....	....	14.20	8.40	10.50	3.92	9.10	2.78	7.96	2.02	5.13	0.68
5500	....	....	....	....	....	....	....	....	....	....	....	....	11.55	4.65	10.01	3.30	8.78	2.39	5.64	0.82
6000	....	....	....	....	....	....	....	....	....	....	....	....	12.60	5.50	10.92	3.90	9.56	2.60	6.15	0.96
6500	....	....	....	....	....	....	....	....	....	....	....	....	13.65	6.45	11.83	4.55	10.36	3.32	6.66	1.06
7000	....	....	....	....	....	....	....	....	....	....	....	....	14.70	7.15	12.74	5.08	11.12	3.68	7.18	1.28
7200	....	....	....	....	....	....	....	....	....	....	....	....	....	....	13.10	5.45	11.50	3.96	7.38	1.35
7500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	13.65	5.90	11.95	4.28	7.66	1.45
8000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8.17	1.63
8500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8.68	1.83
9000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	9.20	2.04
9500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	9.70	2.23
10000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10.40	2.53

Vel.—Velocity ft. per second. Fric.—Friction Head in Feet.

FRICTION OF WATER IN 90° ELBOWS AND EQUIVALENT NUMBER OF FEET STRAIGHT PIPE

From Standard of Hydraulic Society

Size of Elbow, Inches	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10	12	14	15	16	20
Friction Equivalent Feet Straight Pipe	5	6	6	8	8	8	11	15	16	18	18	24	30	40	54	55	55	70

Relative Carrying Capacities of Pipe Lines of Equal Smoothness

Prepared by Emil L. Nuebling for the Reading Meter Repair Co.

Diameter of Pipes	⅛	¼	⅜	½	¾	1	1¼	1½	2	2½
26										348.81
24										285.55
22										229.20
20									316.23	181.02
18									243.00	139.10
16								371.60	181.02	103.62
15								316.23	154.05	88.18
14							419.80	266.13	129.64	74.21
12							285.55	181.02	88.18	50.48
10						316.23	181.02	114.76	55.90	32.00
9						243.00	139.10	88.18	42.96	24.65
8					371.60	181.02	103.62	65.69	32.00	18.32
7					266.13	129.64	74.21	47.05	22.92	13.12
6					181.02	88.18	50.48	32.00	15.59	8.92
5				316.23	114.76	55.90	32.00	20.29	9.88	5.66
4½				243.00	88.18	42.96	24.65	15.59	7.59	4.35
4			371.60	181.02	65.69	32.00	18.32	11.61	5.66	3.24
3½			266.13	129.64	47.05	22.92	13.12	8.32	4.05	2.32
3			181.02	88.18	32.00	15.59	8.92	5.66	2.76	1.58
2½		316.23	114.76	55.90	20.29	9.88	5.66	3.59	1.75	1.00
2		181.02	65.69	32.00	11.61	5.66	3.24	2.05	1.00	
1½		88.18	32.00	15.59	5.66	2.76	1.58	1.00		
1¼	316.23	55.90	20.29	9.88	3.59	1.75	1.00			
1	181.02	32.00	11.61	5.66	2.05	1.00				
¾	88.18	15.59	5.66	2.05	1.00					
½	32.00	5.66	2.05	1.00						
⅜	15.59	2.76	1.00							
¼	5.66	1.00								
⅛	1.00									

Diameter of Pipes	3	3½	4	4½	5	6	7	8	9	10
48			498.83	371.60	285.55	181.02	123.13	88.18	65.69	50.48
46			448.48	334.09	256.73	162.75	110.70	79.10	59.06	45.38
44			401.31	298.96	229.20	145.63	99.29	70.94	52.85	40.61
42			357.25	243.00	204.50	129.64	88.18	63.15	47.05	36.15
40			316.23	235.57	181.02	114.76	78.06	55.90	41.64	32.00
38		388.41	278.17	207.22	159.23	100.94	68.66	49.17	36.63	28.15
36		339.30	243.00	181.02	139.10	88.18	59.98	42.96	32.00	24.65
34		294.12	210.64	156.92	120.58	76.44	51.99	37.24	27.74	21.32
32		252.76	181.02	134.85	103.62	65.69	44.68	32.00	23.84	18.32
30	316.23	215.10	154.05	114.76	88.18	55.90	38.02	27.23	20.29	15.59
28	266.13	181.02	129.64	96.57	74.21	47.05	32.00	22.92	17.07	13.12
26	221.12	150.41	107.72	80.24	61.66	39.09	26.59	19.04	14.18	10.90
24	181.02	123.13	88.18	65.69	50.48	32.00	21.77	15.59	11.61	8.92
22	145.63	99.29	70.94	52.85	40.61	25.74	17.51	12.54	9.34	7.18
20	114.76	78.06	55.90	41.64	32.00	20.29	13.80	9.88	7.36	5.66
18	88.18	59.98	42.96	32.00	24.65	15.59	10.60	7.59	5.66	4.35
16	65.69	44.68	32.00	23.84	18.32	11.61	7.90	5.66	4.21	3.24
15	55.90	38.02	27.23	20.29	15.59	9.88	6.72	4.81	3.59	2.76
14	47.05	32.00	22.92	17.07	13.12	8.32	5.66	4.05	3.02	2.32
12	32.00	21.77	15.59	11.61	8.92	5.66	3.85	2.76	2.05	1.58
10	20.29	13.80	9.88	7.36	5.66	3.59	2.44	1.75	1.30	1.00
9	15.59	10.60	7.59	5.66	4.35	2.76	1.83	1.34	1.00	
8	11.61	7.90	5.66	4.21	3.24	2.05	1.40	1.00		
7	8.32	5.66	4.05	3.02	2.32	1.47	1.00			
6	5.66	3.85	2.76	2.05	1.58	1.00				
5	3.59	2.44	1.77	1.30	1.00					
4½	2.76	1.83	1.34	1.00						
4	2.05	1.40	1.00							
3½	1.47	1.00								
3	1.00									

Diameter of Pipes	12	14	15	16	18	20	22	24	26	28
48	32.00	21.77	18.32	15.59	11.61	8.92	7.03	5.66	4.63	3.85
46	28.77	19.57	16.47	14.02	10.44	8.02	6.32	5.09	4.16	3.46
44	25.74	17.51	14.71	12.54	9.34	7.17	5.66	4.55	3.73	3.10
42	22.92	15.59	13.12	11.16	8.32	6.39	5.04	4.05	3.32	2.76
40	20.29	13.80	11.61	9.88	7.36	5.66	4.46	3.59	2.94	2.44
38	17.84	12.14	10.21	8.69	6.48	4.98	3.92	3.15	2.58	2.17
36	15.59	10.60	8.92	7.59	5.66	4.35	3.43	2.76	2.26	1.83
34	13.51	9.19	7.74	6.58	4.90	3.77	2.97	2.39	1.96	1.62
32	11.61	7.90	6.65	5.66	4.21	3.24	2.55	2.05	1.68	1.40
30	9.88	6.72	5.66	4.81	3.59	2.76	2.17	1.75	1.43	1.19
28	8.32	5.66	4.76	4.05	3.02	2.32	1.83	1.47	1.20	1.00
26	6.91	4.70	3.96	3.37	2.51	1.93	1.52	1.22	1.00	
24	5.66	3.85	3.24	2.76	2.05	1.58	1.24	1.00		
22	4.55	3.10	2.61	2.22	1.65	1.27	1.00			
20	3.59	2.44	2.05	1.75	1.30	1.00				
18	2.76	1.83	1.58	1.34	1.00					
16	2.05	1.40	1.18	1.00						
15	1.75	1.19	1.00							
14	1.47	1.00								
12	1.00									

Diameter of Pipes	30	32	34	36	38	40	42	44	46	48
48	3.24	2.76	2.37	2.05	1.80	1.58	1.40	1.24	1.11	1.00
46	2.91	2.48	2.13	1.85	1.61	1.42	1.26	1.12	1.00	
44	2.61	2.22	1.91	1.65	1.44	1.27	1.12	1.00		
42	2.32	1.97	1.70	1.47	1.28	1.13	1.00			
40	2.05	1.75	1.50	1.30	1.14	1.00				
38	1.81	1.54	1.32	1.14	1.00					
36	1.58	1.34	1.15	1.00						
34	1.37	1.16	1.00							
32	1.18	1.00								
30	1.00									

The foregoing tables will be found useful in proportioning distribution lines.

Example: To find how many one-half inch pipes can be supplied by a 4-in. line, follow down the ½-in. vertical column to the number opposite 4-in. diameter of the first column, where the number 181.02 is found, which is the number of one-half inch lines that can be supplied by a 4-in. line.

Example: To find how many 12-in. lines can be supplied by a 48-in. line, follow horizontally along the 48-in. diameter of the first column, until you reach the 12-in. vertical column, where the number 32 is found, which is the result desired.

INCHES IN DECIMALS OF A FOOT

Fraction of an inch	1/16	3/32	⅛	5/32	¼	9/32	⅜	½	⅝	¾	⅞
Decimal of a foot	.0052	.0078	.0104	.0156	.0208	.0260	0313	.0417	.0521	.0625	.0729
Inches	1	2	3	4	5	6	7	8	9	10	11
Decimal of a foot	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167

Loss of Head Tables

From Handbook American Cast Iron Pipe Co.

LOSS OF HEAD IN PIPES BY FRICTION

Loss of head by friction in each 100 feet in length of different diameters of pipe when discharging the following quantities of water per minute. (Pelton Water-wheel Co.)

Velocity in feet per second V	Inside Diameter of Pipe in Inches: 4 — Loss of head in feet h	4 — Cubic feet per minute Q	6 — Loss of head in feet h	6 — Cubic feet per minute Q	8 — Loss of head in feet h	8 — Cubic feet per minute Q	10 — Loss of head in feet h	10 — Cubic feet per minute Q	12 — Loss of head in feet h	12 — Cubic feet per minute Q
2.0	.593	10.4	.395	23.5	.296	41.9	.237	65.4	198	94.2
3.0	1.22	15.7	815	35.3	.611	62.8	.488	98.2	407	141.
4.0	2.05	20.9	1.37	47.1	1.027	83 7	.822	131.	.685	188.
5.0	3.08	26.2	2.05	58.9	1.54	105	1.23	163.	1.028	235.
6.0	4.31	31.4	2.87	70.7	2.15	125	1.71	196.	1.43	283.
7.0	5.72	36.6	3 81	82.4	2.85	146	2.28	229.	1.91	330.
	14		16		20		24		30	
2.0	.169	128	147	167	119	262	.098	377	.079	589
3.0	.349	192	303	251	245	393	.204	565	163	883
4.0	.587	256	513	335	410	523	.342	754	.273	1178
5.0	.881	321	770	419	617	654	.513	942	411	1472
6.0	1 229	385	1.076	502	861	785	.717	1131	.574	1767
7.0	1.63	449	1 43	586	1.143	916	.953	1319	.762	2061

Example.—Given 200 feet head and 600 feet of 12-inch pipe, carrying 141 cubic feet of water per minute. To find effective head. In right-hand column, under 12-inch pipe, find 141 cubic feet; opposite this will be found the loss by friction in 100 feet length for this amount of water, which is .407 Multiply this by the number of hundred feet of pipe, which is 6, and we have 2.44 feet, which is the loss of head.

Therefore, the effective head is 200 minus 2.44 is 197.56

FRICTION OF WATER IN PIPES

Loss in pounds pressure per square inch by friction for each 100 feet of straight smooth pipe, discharging the stated quantities per minute

U. S Gallons	SIZES OF PIPE: 1 in.	1¼ in.	2 in.	2½ in.	3 in	4 in.	6 in.	8 in.	10 in.	12 in.	14 in	16 in.	18 in	20 in.	24 in	30 in.	Imp. Gallons
5	0 84	0 12															4
10	3 16	0 47	0 12														8
15	6 98	0 97	0 27														12
20	12 3	1 66	0 42														16
25	19 0	2 62	0 67	0 21													20
30	27 5	3 75	0 91	0 30													25
35	37 0	5 05	1 26	0 42	0 14												29
40	48 0	6 52	1 60	0 51	0 17												33
45		8 15	2 01	0 61	0 27												37
50		10 0	2 44	0 81	0 35	0 09											41
75		22 4	5 32	1 80	0 74	0 21											62
100		39 0	9 46	3 20	1 31	0 33	0 05										83
125		48 1	14 9	4 89	1 99	0 51	0 07										103
150			21 2	7 00	2 85	0 69	0 10	0 02									124
175			28 1	9 46	3 85	0 95	0 14	0 03									145
200			37 5	12 47	5 02	1 22	0 17	0 04	0 01								166
250			47 7	19 66	7 76	1 89	0 26	0 06	0 02								207
300				28 06	11 20	2 66	0 37	0 09	0 03	0 005							249
350				33 41	15 20	3 65	0 50	0 11	0 05	0 007	004						290
400				42 96	19 50	4 73	0 65	0 15	0 06	0 010	005	.001					332
450					25 00	6 01	0 81	0 20	0 08	0 020	008	004					373
500					30 80	7 43	0 96	0 25	0 09	0 041	017	009	005				415
600						9 54	1 41	0 39	0 14	0 070	026	014	007				500
700						14 32	1 89	0 47	0 18	0 080	034	017	010	002			583
800							2 39	0 61	0 22	0 090	045	023	012	004			666
900							2 60	0 78	0 27	0 110	055	028	015	.008	.001		749
1000							3 88	0 94	0 32	0 130	.062	036	020	.012	.005	.002	830
1250								1 46	0 49	0.200	.091	049	028	.021	009	.003	1037

Interest and Annuity Tables

From Handbook Cast Iron Pipe Publicity Bureau

COMPOUND INTEREST TABLE

Giving Value of $1 at End of Any Year, From 1 to 100

Years	4%	4½%	5%	5½%	6%	6½%	7%
1	1.0400	1.0450	1.0500	1.0550	1.0600	1.0650	1.0700
2	1.0816	1.0920	1.1025	1.1130	1.1236	1.1342	1.1449
3	1.1249	1.1412	1.1576	1.1742	1.1910	1.2079	1.2250
4	1.1699	1.1925	1.2155	1.2388	1.2625	1.2865	1.3108
5	1.2167	1.2462	1.2763	1.3070	1.3382	1.3701	1.4026
6	1.2653	1.3023	1.3401	1.3788	1.4185	1.4591	1.5007
7	1.3159	1.3609	1.4071	1.4547	1.5036	1.5540	1.6058
8	1.3686	1.4221	1.4775	1.5347	1.5938	1.6550	1.7182
9	1.4233	1.4861	1.5513	1.6191	1.6895	1.7626	1.8385
10	1.4802	1.5530	1.6289	1.7081	1.7908	1.8771	1.9672
11	1.5395	1.6229	1.7103	1.8021	1.8983	1.9992	2.1049
12	1.6010	1.6959	1.7959	1.9012	2.0122	2.1291	2.2522
13	1.6651	1.7722	1.8856	2.0058	2.1329	2.2675	2.4098
14	1.7317	1.8519	1.9799	2.1161	2.2609	2.4149	2.5785
15	1.8009	1.9353	2.0789	2.2325	2.3966	2.5718	2.7590
16	1.8730	2.0224	2.1829	2.3553	2.5404	2.7390	2.9522
17	1.9479	2.1134	2.2920	2.4848	2.6928	2.9170	3.1588
18	2.0258	2.2085	2.4066	2.6215	2.8543	3.1067	3.3799
19	2.1068	2.3079	2.5270	2.7656	3.0256	3.3086	3.6165
20	2.1911	2.4117	2.6533	2.9178	3.2071	3.5236	3.8697
21	2.2788	2.5202	2.7860	3.0782	3.3996	3.7527	4.1406
22	2.3699	2.6337	2.9253	3.2475	3.6035	3.9966	4.4304
23	2.4647	2.7522	3.0715	3.4262	3.8197	4.2564	4.7405
24	2.5633	2.8760	3.2251	3.6146	4.0489	4.5331	5.0724
25	2.6658	3.0054	3.3864	3.8134	4.2919	4.8277	5.4274
26	2.7725	3.1407	3.5557	4.0231	4.5494	5.1415	5.8074
27	2.8834	3.2820	3.7335	4.2444	4.8223	5.4757	6.2139
28	2.9987	3.4297	3.9201	4.4778	5.1117	5.8316	6.6488
29	3.1187	3.5840	4.1161	4.7241	5.4184	6.2107	7.1143
30	3.2434	3.7453	4.3219	4.9840	5.7435	6.6144	7.6123
31	3.3731	3.9139	4.5380	5.2581	6.0881	7.0443	8.1451
32	3.5081	4.0900	4.7649	5.5473	6.4534	7.5022	8.7153
33	3.6484	4.2740	5.0032	5.8524	6.8406	7.9898	9.3253
34	3.7943	4.4664	5.2533	6.1742	7.2510	8.5092	9.9781
35	3.9461	4.6673	5.5160	6.5138	7.6861	9.0623	10.6766
36	4.1039	4.8774	5.7918	6.8721	8.1473	9.6513	11.4239
37	4.2681	5.0969	6.0814	7.2501	8.6361	10.2786	12.2236
38	4.4388	5.3262	6.3855	7.6488	9.1543	10.9467	13.0793
39	4.6164	5.5659	6.7048	8.0695	9.7035	11.6583	13.9948
40	4.8010	5.8164	7.0400	8.5133	10.2857	12.4161	14.9745
41	4.9931	6.0781	7.3920	8.9815	10.9029	13.2231	16.0227
42	5.1928	6.3516	7.7616	9.4755	11.5570	14.0826	17.1443
43	5.4005	6.6374	8.1497	9.9967	12.2505	14.9980	18.3444
44	5.6165	6.9361	8.5572	10.5465	12.9855	15.9729	19.6285
45	5.8412	7.2482	8.9850	11.1266	13.7646	17.0111	21.0025
46	6.0748	7.5744	9.4343	11.7385	14.5905	18.1168	22.4726
47	6.3178	7.9153	9.9060	12.3841	15.4659	19.2944	24.0457
48	6.5705	8.2715	10.4013	13.0653	16.3939	20.5485	25.7289
49	6.8333	8.6437	10.9213	13.7838	17.3775	21.8842	27.5299
50	7.1067	9.0326	11.4674	14.5420	18.4202	23.3067	29.4570
51	7.3910	9.4391	12.0408	15.3418	19.5254	24.8216	31.5190
52	7.6866	9.8639	12.6428	16.1856	20.6969	26.4350	33.7253
53	7.9941	10.3077	13.2749	17.0758	21.9387	28.1533	36.0861
54	8.3138	10.7716	13.9387	18.0149	23.2550	29.9833	38.6122
55	8.6464	11.2563	14.6356	19.0058	24.6503	31.9322	41.3150
56	8.9922	11.7628	15.3674	20.0511	26.1293	34.0078	44.2071
57	9.3519	12.2922	16.1358	21.1539	27.6971	36.2183	47.3015
58	9.7260	12.8455	16.9426	22.3174	29.3589	38.5725	50.6127
59	10.1150	13.4234	17.7897	23.5448	31.1205	41.0797	54.1555
60	10.5196	14.0274	18.6792	24.8398	32.9877	43.7498	57.9464
61	10.9404	14.6586	19.6131	26.2060	34.9670	46.5936	62.0027
62	11.3780	15.3183	20.5938	27.6473	37.0650	49.6222	66.3429
63	11.8332	16.0076	21.6235	29.1679	39.2889	52.8476	70.9869
64	12.3065	16.7279	22.7047	30.7721	41.6462	56.2827	75.9559
65	12.7987	17.4807	23.8399	32.4646	44.1450	59.9411	81.2729
66	13.3107	18.2673	25.0319	34.2501	46.7937	63.8372	86.9620
67	13.8431	19.0894	26.2835	36.1339	49.6013	67.9867	93.0493
68	14.3968	19.9484	27.5977	38.1213	52.5774	72.4058	99.5627
69	14.9727	20.8461	28.9775	40.2179	55.7320	77.1122	106.5321
70	15.5716	21.7841	30.4264	42.4299	59.0759	82.1245	113.9894
71	16.1945	22.7644	31.9477	44.7636	62.6205	87.4626	121.9686
72	16.8423	23.7888	33.5451	47.2256	66.3777	93.1476	130.5065
73	17.5160	24.8593	35.2224	49.8230	70.3604	99.2022	139.6419
74	18.2166	25.9780	36.9835	52.5632	74.5820	105.6504	149.4168
75	18.9453	27.1470	38.8327	55.4542	79.0569	112.5176	159.8760
76	19.7031	28.3686	40.7743	58.5042	83.8003	119.8313	171.0673
77	20.4912	29.6452	42.8130	61.7219	88.8284	127.6203	183.0421
78	21.3108	30.9792	44.9537	65.1166	94.1581	135.9156	195.8550
79	22.1633	32.3733	47.2014	68.6980	99.8075	144.7501	209.5648
80	23.0498	33.8301	49.5614	72.4764	105.7960	154.1589	224.2344
81	23.9718	35.3525	52.0395	76.4626	112.1438	164.1792	239.9308
82	24.9307	36.9433	54.6415	80.6681	118.8724	174.8509	256.7260
83	25.9279	38.6058	57.3736	85.1048	126.0047	186.2162	274.6968
84	26.9650	40.3430	60.2422	89.7856	133.5650	198.3202	293.9255
85	28.0436	42.1585	63.2544	94.7238	141.5789	211.2111	314.5003
86	29.1653	44.0556	66.4171	99.9336	150.0736	224.9398	336.5154
87	30.3320	46.0381	69.7379	105.4299	159.0781	239.5609	360.0714
88	31.5452	48.1098	73.2248	111.2286	168.6227	255.1323	385.2764
89	32.8071	50.2747	76.8861	117.3462	178.7401	271.7159	412.2458
90	34.1193	52.5371	80.7304	123.8002	189.4645	289.3775	441.1030
91	35.4841	54.9013	84.7669	130.6092	200.8324	308.1870	471.9802
92	36.9035	57.3718	89.0052	137.7927	212.8823	328.2191	505.0188
93	38.3796	59.9536	93.4555	145.3713	225.6553	349.5534	540.3701
94	39.9148	62.6515	98.1283	153.3667	239.1946	372.2744	578.1960
95	41.5114	65.4708	103.0347	161.8019	253.5463	396.4722	618.6697
96	43.1718	68.4170	108.1864	170.7010	268.7590	422.2429	661.9766
97	44.8987	71.4957	113.5957	180.0896	284.8846	449.6887	708.3150
98	46.6947	74.7130	119.2755	189.9945	301.9776	478.9184	757.8970
99	48.5625	78.0751	125.2393	200.4442	320.0963	510.0481	810.9498
100	50.5049	81.5885	131.5013	211.4686	339.3021	543.2013	867.7163

ANNUITY TABLE

Giving Yearly Payments Required to Redeem $100 (Per Cent.) at End of Any Year, From 1 to 100

Years	2½%	3%	3½%	4%	4½%	5%	6%
1	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2	49.38	49.26	49.14	49.02	48.90	48.78	48.54
3	32.51	32.36	32.19	32.03	31.88	31.72	31.41
4	24.08	23.90	23.73	23.55	23.37	23.20	22.86
5	19.02	18.84	18.65	18.46	18.28	18.10	17.74
6	15.65	15.46	15.27	15.08	14.89	14.70	14.34
7	13.25	13.05	12.85	12.66	12.47	12.28	11.91
8	11.45	11.25	11.05	10.85	10.66	10.47	10.10
9	10.05	9.84	9.64	9.45	9.26	9.07	8.70
10	8.93	8.72	8.52	8.33	8.14	7.95	7.59
11	8.01	7.81	7.61	7.42	7.23	7.04	6.68
12	7.25	7.05	6.85	6.66	6.47	6.28	5.93
13	6.60	6.40	6.21	6.01	5.83	5.65	5.30
14	6.05	5.85	5.66	5.47	5.28	5.10	4.76
15	5.58	5.38	5.18	4.99	4.81	4.63	4.30
16	5.16	4.96	4.77	4.58	4.40	4.23	3.90
17	4.79	4.60	4.40	4.22	4.04	3.87	3.54
18	4.47	4.27	4.08	3.90	3.72	3.55	3.24
19	4.18	3.98	3.79	3.61	3.44	3.27	2.96
20	3.91	3.72	3.54	3.36	3.19	3.02	2.72
21	3.68	3.49	3.30	3.13	2.96	2.80	2.50
22	3.46	3.27	3.09	2.92	2.75	2.60	2.30
23	3.27	3.08	2.90	2.73	2.57	2.41	2.13
24	3.09	2.90	2.73	2.56	2.40	2.25	1.97
25	2.93	2.74	2.57	2.40	2.24	2.10	1.82
26	2.78	2.59	2.42	2.26	2.10	1.96	1.69
27	2.64	2.46	2.29	2.12	1.97	1.83	1.57
28	2.51	2.33	2.16	2.00	1.85	1.71	1.46
29	2.39	2.21	2.04	1.89	1.74	1.60	1.36
30	2.28	2.10	1.94	1.78	1.64	1.51	1.26
31	2.17	2.00	1.84	1.69	1.54	1.41	1.18
32	2.08	1.90	1.74	1.60	1.46	1.33	1.10
33	1.99	1.82	1.66	1.51	1.37	1.25	1.03
34	1.90	1.73	1.58	1.43	1.30	1.18	.96
35	1.82	1.65	1.50	1.36	1.23	1.11	.90
36	1.75	1.58	1.43	1.29	1.16	1.04	.84
37	1.67	1.51	1.36	1.22	1.10	.98	.79
38	1.61	1.45	1.30	1.16	1.04	.93	.74
39	1.54	1.38	1.24	1.11	.99	.88	.69
40	1.48	1.33	1.18	1.05	.93	.83	.65
41	1.43	1.27	1.13	1.00	.89	.78	.61
42	1.37	1.22	1.08	.95	.84	.74	.57
43	1.32	1.17	1.03	.91	.80	.70	.53
44	1.27	1.12	.99	.87	.76	.66	.50
45	1.23	1.08	.95	.83	.72	.63	.47
46	1.18	1.04	.91	.79	.68	.59	.44
47	1.14	1.00	.87	.75	.65	.56	.41
48	1.10	.96	.83	.72	.62	.53	.39
49	1.06	.92	.80	.69	.59	.50	.37
50	1.03	.89	.76	.66	.56	.48	.34
51	.99	.85	.73	.63	.53	.45	.32
52	.96	.82	.70	.60	.51	.43	.30
53	.93	.79	.67	.57	.48	.41	.29
54	.89	.76	.65	.55	.46	.39	.27
55	.87	.73	.62	.52	.44	.37	.25
56	.84	.71	.60	.50	.42	.35	.24
57	.81	.68	.57	.48	.40	.33	.22
58	.78	.66	.55	.46	.38	.31	.21
59	.76	.64	.53	.44	.36	.30	.20
60	.74	.61	.51	.42	.35	.28	.19
61	.71	.59	.49	.40	.33	.27	.18
62	.69	.57	.47	.39	.31	.26	.17
63	.67	.55	.45	.37	.30	.24	.16
64	.65	.53	.44	.35	.29	.23	.15
65	.63	.51	.42	.34	.27	.22	.14
66	.61	.50	.40	.32	.26	.21	.13
67	.59	.48	.39	.31	.25	.20	.12
68	.57	.46	.37	.30	.24	.19	.12
69	.56	.45	.36	.29	.23	.18	.11
70	.54	.43	.35	.27	.22	.17	.10
71	.52	.42	.33	.26	.21	.16	.10
72	.51	.41	.32	.25	.20	.15	.09
73	.49	.39	.31	.24	.19	.15	.09
74	.48	.38	.30	.23	.18	.14	.08
75	.47	.37	.29	.22	.17	.13	.08
76	.45	.35	.28	.21	.16	.13	.07
77	.44	.34	.27	.21	.16	.12	.07
78	.43	.33	.26	.20	.15	.11	.06
79	.41	.32	.25	.19	.14	.11	.06
80	.40	.31	.24	.18	.14	.10	.06
81	.39	.30	.23	.17	.13	.10	.05
82	.38	.29	.22	.17	.13	.09	.05
83	.37	.28	.21	.16	.12	.09	.05
84	.36	.27	.21	.15	.11	.08	.05
85	.35	.26	.20	.15	.11	.08	.04
86	.34	.26	.19	.14	.10	.08	.04
87	.33	.25	.18	.14	.10	.07	.04
88	.32	.24	.18	.13	.10	.07	.04
89	.31	.23	.17	.13	.09	.07	.03
90	.30	.23	.17	.12	.09	.06	.03
91	.30	.22	.16	.12	.08	.06	.03
92	.29	.21	.15	.11	.08	.06	.03
93	.28	.21	.15	.11	.08	.05	.03
94	.27	.20	.14	.10	.07	.05	.03
95	.26	.19	.14	.10	.07	.05	.02
96	.26	.19	.13	.09	.07	.05	.02
97	.25	.18	.13	.09	.06	.04	.02
98	.24	.18	.12	.09	.06	.04	.02
99	.24	.17	.12	.08	.06	.04	.02
100	.23	.16	.12	.08	.06	.04	.02

McWANE CAST IRON PIPE COMPANY

General Offices and Foundries, Birmingham, Ala.

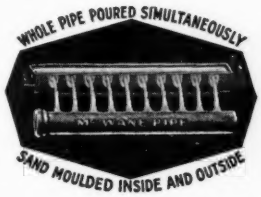
District Sales Offices

123 South Broad St. Philadelphia | 208 So. La Salle St. Chicago | 1807 Santa Fe Bldg. Dallas, Texas

Pacific States Cast Iron Pipe Company

Provo, Utah | 149 W. 2nd South St. Salt Lake City | 111 Sutter St. San Francisco | 417 So. Hill St. Los Angeles | 267 Washington St. Portland

McWane Cast Iron Pipe.—McWane Cast Iron Pipe is of bell and Spigot type, in standard lengths, sand cast, and manufactured in modern weights. It is distinguished by high transverse as well as tensile strength, and cuts and taps and ships particularly well, being a soft, dense-grained gray iron.



Specifications.—McWane Pipe is made of various weights and dimensions, according to the service and pressures for which it is designed. As Class 150 pressures are commonest used, the following table gives the McWane specifications for pipe for that maximum pressure . Those for pipe for higher pressures furnished on request.

McWane Pipe, Class 150 Specifications and Dimensions

Diameter in Inches			Lengths, in feet	Thickness inches	Weight per foot
Nom.	Int.	Ext.			
1¼	1.25	1.75	5	.25	4
2	2.	2.5	6	.25	6
3	3.031	3.656	6	.312	11
4	4.01	4.63	12	.31	15
6	6.15	6.91	16 and 12	.38	25
8	8.22	9.06	16	.42	37
10	10.21	11.09	16	.44	49
12	12.23	13.19	16	.48	63

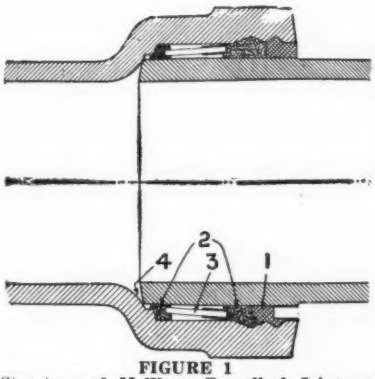


FIGURE 1
Structure of McWane Precalked Joint as Adapted to 1¼, 2, and 3 inch Sizes.
1—Lead. 2—Jute. 3—Iron Wedges.
4—Shoulder of Bell.

The McWane Precalked Joint: As shown in Fig. 1, to the left, this Precalked Joint is factory-made in the bells of McWane Pipe. It is a lead-and-jute joint with a self-tightening feature which prevents leakage under later settlement or movement of the line.

Precalked Joints make it possible to lay Bell and Spigot McWane Pipe without use of lead-pot, or doing any yarning, melting, or pouring on the job. The Joint is **made** in the McWane foundries and merely **finished** in the user's trenches—at "three times the speed for half the cost."

Each Precalked Joint is uniformly and accurately made, carefully inspected, and delivered protected by wooden blocks which preserve it until the pipe is put into service.

Unskilled labor can make tight joints easily and quickly with this Precalked Joint.

Precalked Joint Fittings—exclusive with McWane—contribute largely also to the economy and speed of laying McWane pipe.

Very Small Cast Iron Pipe: The smallest cast iron pipe being made in America is the McWane 1¼-inch size. It, with the McWane 2 and 3 inch, offers water works officials a small diameter pipe at a low cost per foot and lowest cost of all per year. It has all the permanence and desirable qualities of the larger cast iron mains, and makes possible a complete system of one enduring material and proven longevity. The Precalked Joints make it possible to lay McWane small cast iron pipe as rapidly and cheaply as steel pipe.

Intermediate threaded joints, specially reinforced in the McWane types, make it possible also to ship the 2 and 3 inch sizes, in carloads, in 18 foot laying lengths, without resort to welding. Field joints are Precalked lead-and-jute.

Uses of Small Cast Iron Pipe: In addition to the salvage value of using McWane small cast iron pipe wherever perishable pipe is now being used for small-diameter temporary lines, and taking it up to use elsewhere later, it has numerous advantages in the following fields:

Services: A cast iron service is a trouble-free service. Larger capacity, practically endless life, and low cost per foot and per year distinguish it. McWane Bell Braces (see catalog) replace lead goosenecks with it if desired at further savings. Or two meters can be fed through one cast iron service, halving the pipe and trenching cost and making it lower than steel pipe, in cost.

Parallel Mains: In outlying residential blocks and streets, much crossing under costly paving with services can be avoided by running a 2 or 3 inch McWane cast iron main in the parkway down the opposite side of the street from the large fire-protection main. Each side of the street then feeds from its own main, no paving is cut except once to the block for cross-connections, and circulation of water is better. The total cost is less than with one main and numerous longer services crossing the street to each lot.

Golf Courses: Permanent irrigating systems for golf courses, park lawns, cemeteries, etc., are being installed constantly of McWane cast iron pipe. Only McWane makes cast iron pipe small enough to furnish a complete installation in one kind of pipe—from 1¼ inches up through 12 inches. Low cost and freedom from future rust troubles are its advantages for such purposes.

Special Pipe: A number of special types of pipe are also made by this company for use in filter plants, sewage disposal plants, condensers, high pressure gas mains, acid lines, etc. Full details and quotations gladly furnished on receipt of specifications and other details.

Write for McWane catalog.

INDEPENDENT CONCRETE PIPE COMPANY

201 North West St., Indianapolis, Ind.

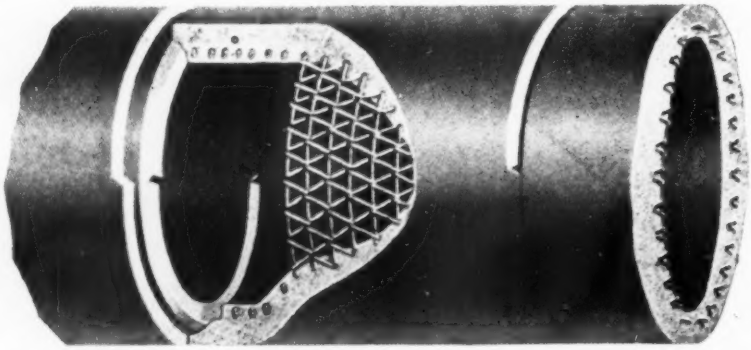
Manufacturers of Reinforced Concrete Pipe

Agencies and Branch Offices in Principal Cities

Products: INDEPENDENT REINFORCED CONCRETE PIPE.

ICPCo. INDEPENDENT CONCRETE PIPE FOR PERMANENCE

The Manufacture of Independent Reinforced Concrete Pipe: The manufacture of Independent Reinforced Concrete Pipe is a simple process. It assures the best quality pipe and, by its very nature, makes inspection and close observation easy during every phase of the work. The reputation of this company has been built on the uniformly excellent quality of its pipe. The company's superintendents, therefore, are men who have a tradition to uphold, and, being responsible for the pipe manufactured on their respective projects, take great pains to produce a high standard of pipe.



Independent Pipe are built to provide recesses to receive the mortar used in sealing the joint. A stiff mortar is trowled into the recess on the inside of the pipe throughout the lower half and into the recess on the outside of the pipe on the upper half of the circumference

Each project is handled as a unit in itself. A trained superintendent is sent into the territory, mixers, tools, forms, and other necessary articles of equipment are shipped to him. Labor, materials, and all other supplies, providing, of course, that they meet the specifications, are obtained locally, so that the manufacture of Independent Reinforced Concrete Pipe becomes a temporary local industry.

The pipe is manufactured either directly along the trench line or in a central pipe yard. In the latter instance, after proper curing, the pipe is delivered along the trench line.

The actual manufacture of Independent Concrete Pipe is in accord with the most highly approved and efficient methods for the manufacture of reinforced concrete pipe under the field method. Building equipment of the finest quality is used. Throughout the entire process the greatest care is exercised to see that each phase of the work is done carefully and satisfactorily thereby insuring a finished product of Independent quality.

To further the care and efficiency of the work on each project, traveling supervisors, coming directly from the home office, visit each project at regular intervals to consult with the superintendent in charge and to make any helpful suggestions or institute any corrective measures that may be needed.

Independent Concrete Pipe can be designed to carry any desired trench load, is easily placed in the ditch, permits immediate backfilling and, due to the smooth internal surface of the pipe, has a carrying capacity excelled by no competitive type of material.

Independent Concrete Pipe is made in sizes from 24 to 108 inches, inclusive. During the operating year 1927, the

The installation of Independent Concrete Pipe at Niles, Illinois, shown above, portrays a difficult delivery, as well as the use of heavy equipment by the contractor. Note that the pipe is laid right up to the point where the trencher is at work

Continued on Next Page

verage size of pipe manufactured by this company was 51 inches.

The recessed joint of Independent Concrete Pipe gives it a distinct advantage over other types of sewer construction, and this advantage is especially important when bad ground conditions, such as wet, caving trenches, are encountered. The joint is so constructed that the recess for the sealing of the pipe on the lower half is on the inside, and the recess on the upper half is on the outside, or top. This permits the pipe to be placed in narrow cuts, sometimes only a few inches wider than the pipe itself, and still gives access to the joint for quick sealing. This quick sealing is particularly advantageous in a trench containing water, where frequently the water can be held back for only a short time. Therefore, regardless of trench conditions, Independent Concrete Pipe is quickly and easily laid, with a tight, dependable joint assured, due to the fact that the joint is visible at all times in the sealing.

TABLE SHOWING DETAIL OF STEEL REINFORCEMENT IN STANDARD INDEPENDENT CONCRETE PIPE

Longitudinals Spaced 4 Inches; Cross Wires Number 14 Gauge Spaced 4 Inches
(From American Steel & Wire Company's "Engineer's Handbook.")

Style Number	Number and Gauge of Wires, each Longitudinal American Steel & Wire Company's Steel Wire Gauge	Sectional Area Longitudinals Square Inches Per Foot Width	Total Effective Longitudinal Sectional Area Square Inches Per Food Width	Approximate Weight, lbs. Per 100 Square Feet
068	1—No. 8 gauge	.062	.068	35
080	1— " 7 "	.074	.080	40
093	1— " 6 "	.087	.093	45
107	1— " 5 "	.101	.107	50
126	1— " 4 "	.120	.126	57
146	1— " 3 "	.140	.146	65
153	1— " ¼ inch	.147	.153	68
168	1—No. 2 gauge	.162	.168	74
180	2— " 6 "	.174	.180	78
208	2— " 5 "	.202	.208	89
245	2— " 4 "	.239	.245	103
267	3— " 6 "	.261	.267	111
287	3— " 5½ "	.281	.287	119
309	3— " 5 "	.303	.309	128
336	3— " 4½ "	.330	.336	138
365	3— " 4 "	.359	.365	149
395	3— " 3½ "	.389	.395	160

TABLE OF DIMENSIONS

Size	Wall Thickness	Total Minimum Cross Sectional Area of Circular Reinforcement per Foot Length of Pipe	Number of Rings
24 in.	3 in.	.068 sq. in.	1
27 in.	3 in.	.080 sq. in.	1
30 in.	3½ in.	.093 sq. in.	1
33 in.	3¾ in.	.107 sq. in.	1
36 in.	4 in.	.126 sq. in.	1
39 in.	4¼ in.	.146 sq. in.	1
42 in.	4½ in.	.153 sq. in.	1
45 in.	4½ in.	.153 sq. in.	1
48 in.	5 in.	.219 sq. in.	2
54 in.	5½ in.	.260 sq. in.	2
60 in.	6 in.	.294 sq. in.	2
66 in.	6½ in.	.333 sq. in.	2
72 in.	7 in.	.361 sq. in.	2
78 in.	8 in.	.413 sq. in.	2
84 in.	8 in.	.425 sq. in.	2
90 in.	8 in.	.495 sq. in.	2
96 in.	8½ in.	.581 sq. in.	2
102 in.	8½ in.	.610 sq. in.	2
108 in.	9 in.	.682 sq. in.	2

Sizes up to and including 72-inch are manufactured in 4-foot lengths, and above 72-inch, in 5-foot lengths.

QUANTITIES OF MATERIAL FOR ONE CUBIC YARD OF CONCRETE IN PLACE

(From Taylor & Thompson's "Concrete, Plain and Reinforced.")

Proportions by Parts			Percentages of Voids in Broken Stone or Gravel								
			50%			45%			40%		
Cement	Sand	Stone	Bbls. Cement	Yds. Sand	Yds. Stone	Bbls. Cement	Yds. Sand	Yds. Stone	Bbls. Cement	Yds. Sand	Yds. Stone
1	1½	2	2.39	0.53	0.71	2.30	0.51	0.68	2.22	0.49	0.66
1	1½	3	2.01	0.45	0.89	1.91	0.42	0.85	1.83	0.41	0.81
1	2	3	1.81	0.54	0.80	1.74	0.52	0.77	1.67	0.50	0.74
1	2	3½	1.69	0.50	0.88	1.61	0.48	0.83	1.54	0.46	0.80
1	2	4	1.58	0.47	0.94	1.51	0.45	0.89	1.44	0.43	0.85
1	2	4½	1.49	0.44	0.99	1.41	0.42	0.94	1.34	0.40	0.89
1	2	5	1.40	0.42	1.04	1.33	0.39	0.98	1.26	0.37	0.93
1	2½	3	1.65	0.61	0.73	1.59	0.59	0.71	1.53	0.57	0.68
1	2½	3½	1.55	0.57	0.80	1.48	0.55	0.77	1.42	0.52	0.74
1	2½	4	1.46	0.54	0.87	1.39	0.51	0.82	1.33	0.49	0.79
1	2½	4½	1.38	0.51	0.92	1.31	0.48	0.87	1.25	0.46	0.83
1	2½	5	1.31	0.48	0.97	1.24	0.46	0.92	1.18	0.44	0.87
1	2½	6	1.18	0.44	1.05	1.12	0.41	1.00	1.06	0.39	0.94
1	3	4	1.35	0.60	0.80	1.30	0.58	0.77	1.25	0.56	0.74
1	3	5	1.22	0.54	0.90	1.16	0.52	0.86	1.11	0.49	0.82
1	3	6	1.11	0.49	0.99	1.06	0.47	0.94	1.01	0.45	0.90
1	3	7	1.02	0.45	1.06	0.97	0.43	1.01	0.92	0.41	0.95
1	4	6	0.99	0.59	0.88	0.95	0.56	0.84	0.91	0.54	0.81
1	4	7	0.92	0.54	0.95	0.88	0.52	0.91	0.83	0.49	0.86
1	4	8	0.86	0.51	1.02	0.81	0.48	0.96	0.77	0.46	0.91

Use 50% columns for broken stone screened to uniform size. Use 45% columns for average conditions and for stone with dust screened out. Use 40% columns for gravel or mixed stone and gravel.

View of a splendid line of 84-inch Independent pipe laid in shale rock at Clawson, Michigan. Notice how smoothly the pipe is laid in the curves

UNITED STATES CAST IRON PIPE & FOUNDRY COMPANY

General Office: Burlington, N. J.

Manufacturers of Cast Iron Pipe—Bell and Spigot, Flange, Flexible Joint, High Pressure, Plain End and Threaded Fittings—Cast Iron Bell and Spigot or Flanged—Standard and Special Castings—Municipal or Hydraulic—Standard or to Engineers' Designs

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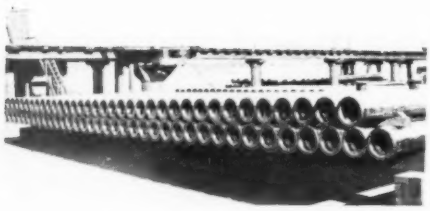


deLavaud Centrifugally Cast Cast-Iron Pipe: Cast Iron Pipe is inherently so satisfactory for underground work that it has been claimed that much improvement was impossible. However, by the utilization of centrifugal force in the manufacture of pipe a method has been developed that produces pipe superior in many respects to that cast in sand molds.

The method used by our company in making centrifugally cast pipe was invented by D. S. deLavaud, a Brazilian engineer, and was perfected commercially by our company. A metal mold is rotated horizontally and at the same time the molten metal is fed into the mold at a uniform rate of flow so that the rotary force throws the metal against the mold forming the pipe. This eliminates the use of all cores except the small core for forming the inside of the bell. The centrifugal force acting on the molten iron forces from the metal all impurities and gives it a very homogeneous structure.

A comparison of the specifications for the two materials show that the metal from pipe cast in sand is required to withstand 20,000 lb. per square inch, as compared to 30,000 lb. per square inch for centrifugally cast metal. Actual tests show, however, that the deLavaud pipe will withstand a much greater load than the 30,000 lb. per square inch required.

Qualities of deLavaud Pipe: deLavaud pipe has an even greater resistance to corrosion than sand cast pipe.
It is cheaper to install, owing to its uniform lead space and self centering bell.

It is easy to cut and tap.

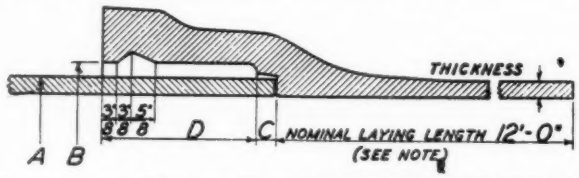
Its greater strength and uniform sections make it valuable for use for higher pressures.

It lends itself particularly well to the use of sleeve joints, due to its smooth exterior and uniform circumference.

deLavaud pipe is made to be used with standard fittings and specials.

As the outside diameters of deLavaud pipe are the same as for sand cast pipe the reduction in thickness results in a larger inside diameter and increased carrying capacity which is further increased by the unusually smooth interior surface of deLavaud pipe.

The method of manufacture of deLavaud cast iron pipe and the product itself have been approved by the Underwriters' Laboratories of the National Board of Fire Underwriters.



Dimensions and Weights of Standard Bell and Spigot deLavaud Pipe

Nominal Diameter Inches	Class or Maximum Working Pressure	Average Thickness	Weight of Pipe Pounds	Weight Per Foot Including Bell
4	50	.30	175	14.6
4	150	.34	200	16.6
4	250	.37	215	17.9
6	50	.32	280	23.3
6	150	.36	310	25.8
6	250	.40	340	28.3
8	50	.36	410	34.2
8	150	.38	435	36.3
8	200	.42	475	39.6
8	250	.46	515	42.9
10	50	.39	540	45.0
10	150	.42	585	48.7
10	200	.48	657	54.7
10	250	.52	705	58.7
12	50	.42	700	58.3
12	150	.46	765	63.7
12	200	.52	850	70.8
12	250	.58	935	77.9
14	50	.44	848	70.7
14	100	.50	931	77.6
14	150	.55	1065	88.7
14	200	.62	1186	98.8
16	50	.45	1000	83.3
16	100	.52	1135	94.6
16	150	.60	1325	110.4
16	200	.66	1442	120.1
18	50	.48	1190	99.2
18	100	.56	1367	113.7
18	150	.64	1579	131.6
18	200	.71	1740	145.0
20	50	.50	1381	115.0
20	100	.59	1599	133.2
20	150	.69	1904	158.7
20	200	.76	2074	172.8

The nominal laying length is given as 12'0" but the actual laying length of full length pipe shown in the table above is 12'1".

Gas Pipe—for average gas installations we recommend Class 150 in diameters 4" to 12" inclusive and Class 100 pipe in diameters 14" to 20" inclusive.

Class 50 pipe are recommended for flow lines, drains, exhaust lines and other low pressure installations where frequent tapping is not required. All weights are approximate and are based on the nominal laying length of 12'0".

Pipe of heavier wall thickness than shown in the above table can be furnished if desired.

Continued on Next Page

Weights of Standard Bell and Spigot deLavaud Pipe 18'0" Nominal Laying Length

Table II

Nominal Diameter, Inches	Class or Maximum Working Pressure	Weight of Pipe Pounds	Weight per Foot Including Bell
4	50	254	14.1
4	150	289	16.0
4	250	311	17.3
6	50	404	22.4
6	150	448	25.0
6	250	493	27.4
8	50	594	33.0
8	150	629	35.0
8	200	688	38.2
8	250	747	41.5
10	50	795	44.2
10	150	849	47.2
10	200	957	53.2
10	250	1028	57.1
12	50	1015	56.4
12	150	1109	61.6
12	200	1238	68.8
12	250	1365	75.8

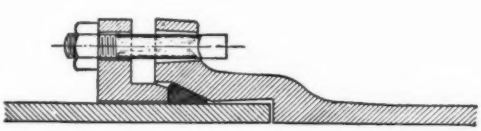
NOTE: Thickness same as in 12 ft. Pipe.

Bell and Plain End Joints: Our deLavaud pipe is regularly equipped with bell and plain end joints similar to the Metropolitan Type of bell. In laying it is only necessary to place the end of one pipe in the bell of the next and slide it forward until it rides upon the taper and automatically centers itself.

Once in place and calked in the usual manner these joints show unusual resistance to blowing out. In a recent test 6-in. joints calked with lead withstood an average of 666 lb. per square inch pressure when the pipe were not restrained against longitudinal motion.

In spite of their strength these joints are very flexible. A joint of this nature after calking was recently deflected until the sections of pipe were at an angle of 12° 56′ before failure. The equivalent radius of curvature for this deflection is about 82 ft. These tests show that the new bell and plain end has all the advantages of the bell and spigot type.

All things considered it is evident that deLavaud centrifugally cast cast-iron pipe is an ideal material for many installations and we believe it is only a question of time before this material will revolutionize the use of pipe in industry.



The Anthony High Pressure Joint: deLavaud centrifugally cast pipe also comes equipped with the Anthony Joint. This joint remains absolutely tight under maximum pressures used for supply or distribution lines and provides for an unusual amount of flexibility.

If desired, deLavaud Pipe can be shipped in 24 ft. lengths with a welded joint in the center of each length. Such an installation as this requires only 220 gaskets to the mile—only one quarter of the usual number.

U. S. Cast Iron Pipe and Fittings: Cast Iron Pipe with bell and spigot joints has long been the standard for water supply and distribution lines. The flexibility of this type of installation makes it ideal under the exacting conditions of this service. All types of fittings are available for use with this pipe. For high pressure service bell and spigot pipe and fittings are equipped with lugs for bolting the joints together.

Castings: Our facilities for handling municipal and hydraulic castings are exceptional. These castings vary in size from 1 lb. to 50 tons and can be finished in accordance with our standards or to your engineer's designs.

Numerous foundries advantageously located make it possible for us to offer unusual service both in manufacture and shipment.

Flanged Pipe: In recent years, the tightness and strength of the flanged joint have become of value for many special purposes. Flanged pipe is very generally used in power stations and similar buildings, where pipe lines are well supported. The dimensions of flanges, drilling, etc., adopted as standard for all flanged pipe except that for gas, are those recently adopted by the Committee of Manufacturers and the American Society of Mechanical Engineers, and known as the "American Standard."

Handbook of Cast Iron Pipe for All Services: A handbook has recently been issued by the Cast Iron Pipe Research Association covering good engineering practice in laying Cast Iron Pipe. This book also contains chapters on the usual problems confronting users of this material. We shall be glad to send a copy to any Engineer interested in piping. Write us for "Handbook of Cast Iron Pipe."

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Continued on Next Page

Mathews Fire Hydrants (Reg. U. S. Pat. Off.) are of particularly substantial, simple construction, and of great economy and flexibility. They are correctly designed to a fundamentally sound principle and meet the most exacting demands of modern water works practice.

The entire barrel, which contains all the working parts including the VALVE SEATS, is removable through the sliding protection case without digging up or disturbing the ground. This brings practically the entire hydrant above ground where the working parts are visible and accessible. Repair work on the ground, particularly in cold or bad weather, is unnecessary. A spare barrel may be kept on hand to quickly replace the one requiring attention.

Because of this feature, **Mathews Hydrants** which may be broken by automobiles, can be quickly replaced without the usual expense of excavating or breaking the pavement.

It is also possible to change both the number and the direction of the nozzles without excavating or disturbing the ground.

Change of Grade—There are several methods of raising the nozzle level of Mathews Hydrants. The methods used depends largely on local conditions.

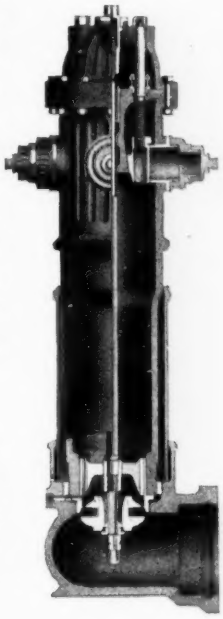
We can furnish an easily installed extension piece which is placed between the elbow and the barrel or standpipe. Another method is to replace the entire barrel and protection case with new ones of proper length—either longer or shorter as the case may be.

Both the above methods require but a small amount of excavation.

A Mathews Hydrant may also be raised **without excavating**, by removing the barrel, placing an inexpensive extension section on top of the casing and inserting a new barrel of proper length.

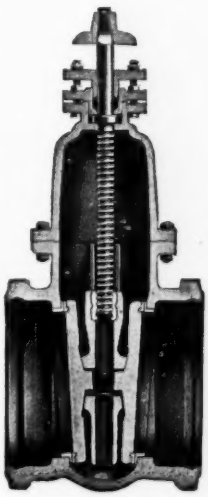
The old barrel may be used on future extensions where the grade is normal.

Mathews' High Pressure Fire Hydrants: Designed along the lines of our Standard Mathews Hydrant, amply strong in all its parts to withstand the severe service for which it is intended. This Hydrant in actual service, has proven itself thoroughly reliable under the high pressure specified by Fire Engineers throughout the country. With this type of hydrant the valve which controls the water is most important—it must be reliable and easy to operate under extremely high working pressure. This has been accomplished by means of a simple but effective relief valve within the main valve, which opens with the first few turns of the wrench, permitting the water to enter the body of the hydrant, equalizing the pressure on the main valve.



A few cities which are being successfully served by Mathews High Pressure Fire Hydrants are—Atlantic City N. J.; Buffalo, N. Y.; Cleveland, Ohio; Toledo, Ohio; Winnipeg, Canada.

"Wood" Gate Valves are designed to A. W. W. A. specifications. They are exceptionally heavy weight—fully bronze mounted and tested to three hundred pounds pressure.



The features making these valves unusually suited for severe underground service are:

Taper Seats—which insure tightness and easy operation.

Independent Revolving Discs—free to revolve and find a new seat each time the valve is operated, preventing unequal wear and leakage.

One Piece Spreader—Simply, but properly designed, easy acting without secondary motion.

Unexcelled Simplicity—Only four internal parts—stem, spreader and two discs. No corners or pockets to accumulate sediment and scale.

R. D. Wood & Company are also prepared to quote on Foot Valves, Check Valves and Cast Iron Extension Valve Boxes, Hydraulically and Electrically Operated Gate Valves, Light Pressure Gate Valves, Intake Screens, Fish Traps, and miscellaneous Water Works Castings.

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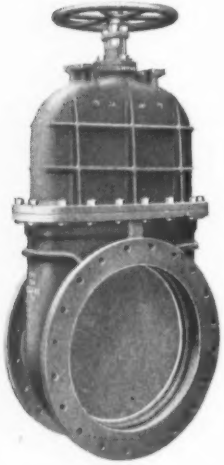
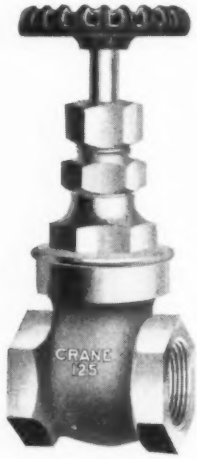
CRANE

The products shown on these two pages only hint at the wide range and extent of the Crane Co. line. More detailed information, specifications, and dimensions of any of the products shown, as well as similar data on all materials made by Crane Co. for water works use, may promptly be secured by addressing the nearest one of the branches listed above. Or a letter to the General Office at 836 S. Michigan Ave., mentioning the piping materials in which you are interested, will bring comprehensive descriptive literature.



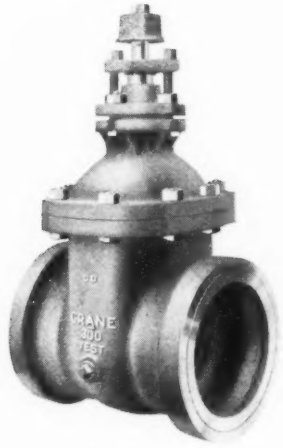
No. 791 Double Disc Gate Valve

No. 791 Double Disc Gate Valve: Low pressure, non-rising stem, with iron body, brass trimmings, and brass stem. For water working pressures up to 30 pounds. Made in sizes from 14 to 72 inches, supplied with and without gear.



No. 438 Wedge Gate Valve

No. 438 Wedge Gate Valve: Brass, non-rising stem, with a gland in the stuffing box. A standard, general service valve, in sizes from ¼-inch to 3-inch, for steam working pressures up to 125 pounds. When wide open, these valves may be repacked while under pressure.

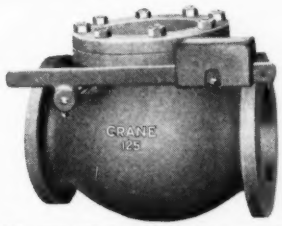


No. 480½ Double Disc Gate Valve

No. 480½ Double Disc Gate Valve: Specifically designed to meet the specifications of the American Water Works Association. Iron body, parallel seats, non-rising stem, hub ends. The discs always ride down to a tight, true position even under the most severe operating conditions. For water working pressures up to 175 pounds. Tested to 300 pounds hydraulic pressure.

No. 373 Swing Check Valve

No. 373 Swing Check Valve: Iron body, brass seat, with brass or leather faced disc. Can be used in horizontal position or for upward flow. In sizes from 2-inch to 30-inch. 16-inch and smaller for steam working pressures up to 125 pounds; above 16-inch, 100 pounds. Water working pressures ratings are 40% higher up to 12-inch, and 20% higher for 14-inch and larger sizes. To order, this valve can be supplied with by-pass.

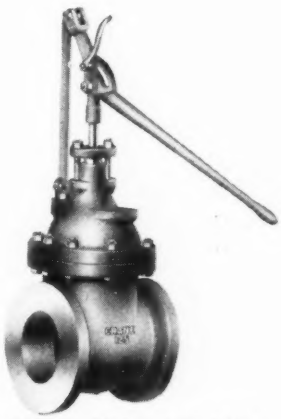


No. 373, With Outside Lever and Weight

No. 373, With Outside Lever and Weight: This check valve is especially adapted to service in connection with centrifugal pumps. The lever and weight feature seats the disc upon the slightest backflow, thereby eliminating the shock which results with ordinary check valves.

No. 525 Standard Flanger Elbow

No. 525 Standard Flanged Elbow: Of cast iron, for steam working pressures up to 125 pounds, or water working pressures 40% higher in 12-inch and smaller size, and 20% higher in 14-inch and larger. Supplied faced or faced and drilled, in sizes from 1¼-inch to 24-inch.

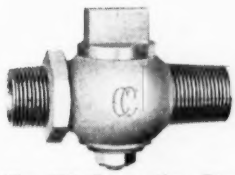


No. 471 Wedge Gate Valve

No. 471, Wedge Gate Valve: Iron body, brass trimmings, with a quick-opening sliding stem. Supplied with flanged or screwed ends. In sizes from 2-inch to 16-inch. For steam working pressures up to 125 pounds; water working pressures 175 pounds for sizes 12-inch and smaller, 150 pounds for 14 and 16-inch.

No. 7 Many Purpose Globe Valve

No. 7 Many Purpose Globe Valve: A screwed end general utility valve of brass with renewable disc; wheels, stuffing box nuts, and union bonnet rings of malleable iron to give strength where wear is hardest. When leaks occur, new disc can be quickly inserted, and the valve—when wide open—can be repacked while under pressure. In sizes from ⅛-inch to 3-inch, for steam working pressures up to 150 pounds, and proportionately higher water working pressures.

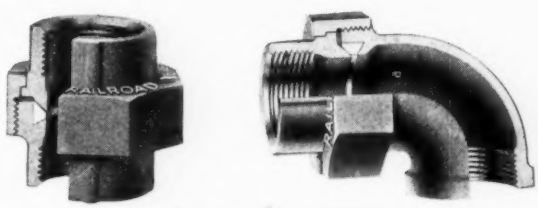


No. 835 Corporation Stop Cock

No. 835 Corporation Stop Cock: Of brass, with coarse thread for wood pipe mains. In four sizes from ½-inch to 1-inch.

Standard Brass Steam Elbow

Standard Brass Steam Elbow: Of high quality brass. For use where service conditions dictate the use of this metal, as well as installations in which brass pipe is preferred or specified.



Unions and Union Fittings

Unions and Union Fittings: No. 519 union and No. 590 union elbow, both with female ends, are representative of a complete line, of malleable iron, with leakproof brass to iron seats, eliminating gaskets and readily taken apart. Tested to 250 pounds hydraulic pressure.

AMERICAN MANGANESE BRONZE COMPANY

Main Office and Works: Holmesburg, Philadelphia, Pa.

Metallurgical Engineers and Founders

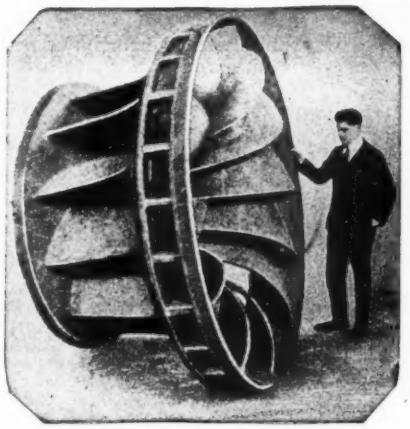
Cleveland: 508 Leader Bldg. Milwaukee: 428 Wisconsin Ave. Pittsburgh: 205 Oliver Bldg. Wyoming, Pa. New York: 225 Broadway

Products: TURBINE RUNNERS, LARGE VALVES AND STEMS (FORGED OR CAST), VALVE OPERATING PARTS, SLUICE GATE ROLLER BEARINGS AND SLIDES, SHAFT CAPS, SCREWED AND FLANGED PIPE FITTINGS, EXPANSION JOINTS, LARGE NEEDLE POINT VALVES.

We have had **more than 20 years experience** in producing high grade bronze products for Hydraulic installations, such as: Catskill Aqueduct, Arrow Rock Dam, Niagara Falls (Canadian and American), Hetch Hetchy, Southern California Edison, Los Angeles Light and Power, Elephant Butte Dam, New York State Barge Canal, Carolina Light and Power Company, Norwood Development, etc.

Our Foundry is one of the largest and best equipped exclusive Bronze Foundries in the United States, and is located on the Main Line of the Penna. R. R. within the limits of Philadelphia. Complete Chemical and Physical Testing Laboratories as well as adequate machining facilities are available.

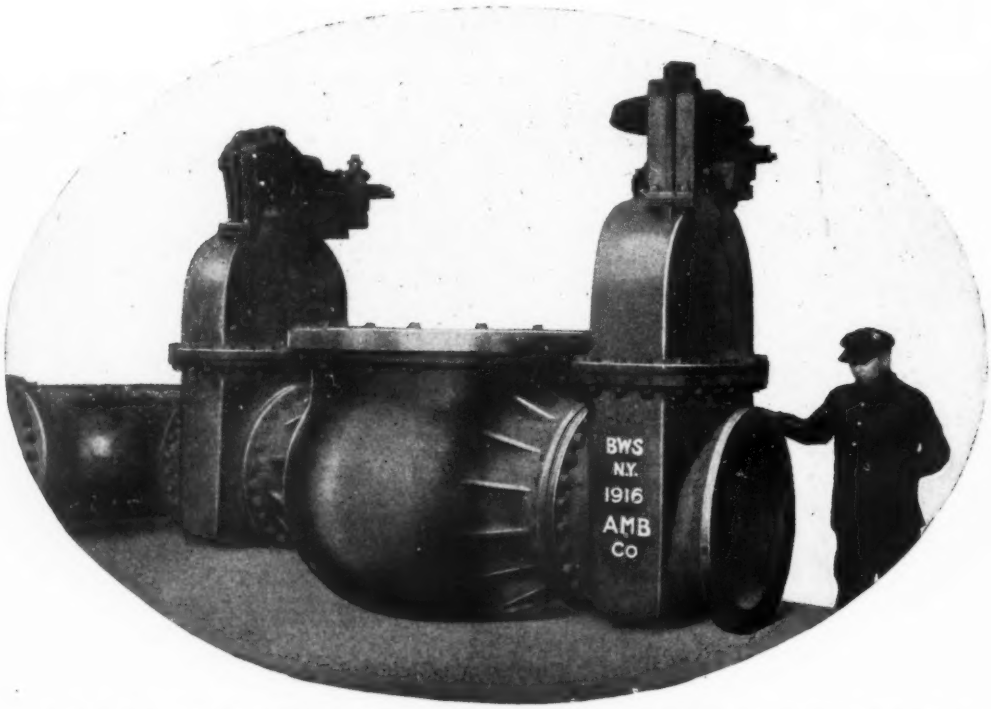
We will furnish upon request our Valve Stem catalog and also our literature on Hy-ten-sl Bronze, **The Strongest of Bronzes.**



One of the Many Bronze Turbine Runners Made by Us—Weight 16,500 Lbs.

The 3 Principal A. M. B. Co. Metals used are:

1. HY-TEN-SL BRONZE
   (Nos. 1 to 4)
   85,000 to 120,000 lbs. T. S.
2. S. M. B. MANG BRONZE
   75,000 lbs. T. S.
3. TURBINE RUNNER BRONZE
   (Erosion Resisting)
   80,000 lbs. T. S.



A. M. B. Bronze Shaft Cap with 30 Hydraulic Bronze Gate Valves and Flanged Fittings Supplied New York Board of Water Supply for Catskill Aqueduct

GOLDEN-ANDERSON VALVE SPECIALTY COMPANY

1386 Fulton Building, Pittsburgh, Pa.

Automatic Cushioned Controlling Altitude Valves

Products: GOLDEN-ANDERSON AUTOMATIC CUSHIONED CONTROLLING ALTITUDE VALVES.

"Always Cushioned in Closing and Opening."

1. They keep the water level constant in reservoirs, standpipes, tanks, etc., under all conditions.
2. Very simple in design. Contain no floats or fixtures inside or outside the tanks.
3. A perfect cushion by water and air absolutely prevents water hammer, surges and broken mains. No metal-to-metal seats.
4. Can be closed in three ways: by hand, automatically by water if a pipe breaks, and by electricity from distant points.
5. When desired, can be connected to work "both ways" on a single pipe line.

No metal-to-metal seats, no water hammer.

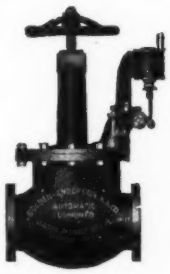
"Made with Stop-Starter Attachments for Centrifugal Pumps."

All the annoyances of freezing are eliminated.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. *"No valves or fixtures inside." "No fixtures outside of tanks."* Sizes to 24 inches.

Hosts of references. "Every valve with an absolute guarantee."

"Heaviest Valves Made"



Golden-Anderson Pat. Cushioned Electric Water Service Valves.

1. Give instant control of water distribution from pumping station in case of fire.
2. Open or close by electricity from distant point—a.c. or d.c. circuits. Also close by hand.
3. No waste of electricity. Current is on only few seconds.
4. Cushioned in opening and closing.
5. No water hammer, shock, sticking, surging or chattering.

Golden-Anderson Pat. Automatic Cushioned Water Pressure Regulating Valves.

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required —No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

Golden-Anderson Pat. Automatic Cushioned Water Float Valves.

1. Automatically maintain uniform water levels in tanks standpipes, etc.
2. Instantly adjusted to operate quickly or slowly.
3. Floats swivel to any angle—Most satisfactory float valves known.
4. No metal-to-metal seats — No water hammer or shock.
5. Cushioned by water and air. sizes ½ to 24 in.

Golden-Anderson Patented Automatic Cushioned Controlling Float Valve.

1. Automatically maintains uniform level in heaters, tanks, etc.
2. Air and water cushioned.
3. No metal-to-metal seats.
4. No waste of water.
5. No water hammer or shock.
6. Angle and Globe patterns to 24 in.

Golden-Anderson Pat. Cushioned Water Relief Valves.

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and Globe patterns. Sizes 3 to 24 in.

Golden-Anderson Pat. Automatic Double Cushioned Check Valves.

1. Especially adapted for water service.
2. For high or low pressure.
3. Thoroughly cushioned. No chattering hammering or sticking.
4. Globe or Angle patterns up to 24 in.
5. Especially adapted for hydraulic elevator service.

Cushioning is of vital importance.

Safety demands perfect cushioning.

Water Taps by Whom Made and Costs

The following interesting information on the installation of water taps and connections in the state of New York is taken from *Water Works*. A questionnaire was sent to various municipalities and from their replies the report was compiled.

Who Pays for the Water Tap?—Fifty-eight municipalities reported that the consumer paid for the water tap and connections in their cities. Five cities reported that the consumer did not pay these costs.

Albion reports that connections on mains only were made by the village, all other costs being paid by the consumer. At Cortland the property owner pays for the water tap and connections. Cohoes reported that the consumer pays for corporation cocks and tapping main, and that the consumer does the excavating and backfilling. At Illion the consumer pays for the water tap and connections and also the cost of making cuts in the street and repairing them. At Medina the consumer pays for the cost from residence to curb, while at North Tonawanda he pays for the tap only. At Ogdensburg the consumer pays the costs for installation from outer edge of sidewalk to house only. At Sherrill the consumer pays the largest part of the cost, while at Tarrytown he pays for tap only. At Seneca Falls the company brings the service as far as the curb, and the consumer pays for the balance of the work. At Saranac Lake the village furnishes the tap and the consumer pays for corporation and curb cocks.

Who Does This Work?—Thirty-two cities reported that the municipality did the work of installing water taps and connections, while 12 cities reported that they didn't do this work. Albion makes the tap, while Auburn makes the installation as far as the curb. Amsterdam does the work only when connections are in excess of 1 in.; smaller taps are done by plumbers. Binghamton does the work from main to curb, while Batavia makes the taps, the connections being made by the property owner under supervision of the city. Cortland makes only large taps for fire protection. Fulton and Gloversville do only the work to the curb. Ithaca taps main only. Kenmore, Little Falls, Middletown, Mount Vernon, Newburgh, Rochester, Sherrill, Tonawanda and Waverly make the tap only. At Olean the city lets contract to lowest bidder and work is done under city inspector. Scotia makes the tap and furnishes the connections only. At Schenectady the city makes taps. Plumber gives 24 hours notice when trench will be opened in readiness for making tap. Plumber furnishes all material except corporation cock, curb cock and cock box. These are included in the charge for the tap. At Saranac Lake the municipality furnishes the labor and the consumer pays for the brass connections. Walden makes tap free of charge, but property owner does all excavation and pays for all material furnished. At Mechanicsville the work is done by the municipality. Any licensed plumber may do the work under the instructions of the commissioner of public works.

Charges for Making Taps and Connections.—The replies to the question, "If the municipality does the work, what charge or charges does it make for making such water tap and connection?" are summarized as follows in the report:

Albion—No charge for making tap.

Auburn—Actual cost of work.

Amsterdam—Actual cost. For excavation on dirt street a deposit of $10, practically all rebate; for excavation of good macadam a deposit of $20 cost charge; for excavation of brick and concrete a deposit of $5 for lineal foot, charges deducted from deposit.

Binghamton—For ¾ in. tap, $22, and for 1 in. tap, $30. $10 extra for pavement cut.

Batavia—For ¾ in. tap, $3; for 1 in. tap, $3.50. All excavating and laying of service pipe done by and at expense of owner.

Beacon—½ in. tap, $2.50; ¾ in., $3.00. Extra or additional taps, $1.50; sewer taps, $1.50.

Buffalo—Bureau of Water installs all taps and makes all branch connections. Plumber is required to make application and payment for any taps required. In case of a connection larger than 3 in. he must make a deposit of a certain amount. After city's work is done it either bills him for the difference or refunds any excess amount paid. All excavating must be done by plumber or contractor. Following are the charges for taps and deposits for connections:

⅝ in., $4; ¾ in., $5; 1 in., $7; 1½ in., $10; 2 in., $15.

Deposits:

4 in. x 4 in.	$ 70	10 in. x 8 in.	$140
6 in. x 4 in.	95	12 in. x 8 in.	160
8 in. x 4 in.	100	16 in. x 8 in.	185
10 in. x 4 in.	110	20 in. x 8 in.	205
12 in. x 4 in.	130	10 in. x 10 in.	165
16 in. x 4 in.	155	12 in. x 10 in.	185
20 in. x 4 in.	165	16 in. x 10 in.	205
6 in. x 6 in.	105	20 in. x 10 in.	225
8 in. x 6 in.	110	12 in. x 12 in.	215
10 in. x 6 in.	125	16 in. x 12 in.	220
12 in. x 6 in.	145	20 in. x 12 in.	240
16 in. x 6 in.	170	20 in. x 16 in.	330
20 in. x 6 in.	180		

Cortland—Time and material costs 20 per cent.

Corning—

	Cost of taps to curb
⅝ in.	$20.50
¾ in.	27.00 Manifold
1 in.	24.00
1 in.	32.00 Manifold
1½ in.	44.00
2 in. tap from 4 in. main	$ 46.00
2 in. tap from 6 in. main	52.00
3 in. tap from 4 in. main	54.00
3 in. tap from 6 in. main	58.00
4 in. tap from 4 in. main	60.00
4 in. tap from 6 in. main	66.00
6 in. tap from 6 in. main	84.00
2 in. tap from 8 in. main	56.00
4 in. tap from 8 in. main	70.00
3 in. tap from 8 in. main	62.00
6 in. tap from 8 in. main	110.00

Cohoes—$5 for ¾ in. and $8 for 1 in. cock and tap.

Catskill—Labor and material.

Canandaigua—$5.

Elmira—A ¾ in. tap and service line from main to cellar costs the consumer $28 as a minimum charge for everything up to 40 ft. All distance over 40 ft. is paid for at the rate of $0.50 per foot. Pipe is laid 5½ ft. deep. All other sizes of service are put in at cost, from main to cellar. When streets are about to be paved we lay ¾ in. AAA lead pipe to the curb for every vacant lot. If for any reason a pavement has to be disturbed to make a connection the consumer pays the pavement repairs as a part of the charge for the service. The charge for service from main to curb is in lieu of frontage tax.

Fulton—A deposit of $15 is required before making tap. Actual cost of corporation, pipe, goose neck, curb stop and box are charged to consumer plus labor of putting same in. City does not dig or back fill trench. Difference between deposit of $15 and actual cost is refunded to consumer.

Floral Park—It is necessary in the village to obtain a street permit. This must be taken out by a bonded plumber. Cost of the permit is $2.50 and the amount of $25 must be deposited. After street is put back in shape and after an inspection $10 is returned to the applicant and the other $15 retained by the village towards repairing such cuts in street.

Freeport—½ in. tap $7.50; 1 in. tap $10; two ½ in. taps, one excavation, $10; two 1 in. taps, one excavation, $15. This has nothing to do with street opening. Plumbers are bonded to replace streets, and this applies to all classes.

Geneva—½ in. tap $5.75; ¾ in. tap $7.50; 1 in. tap and up $12; 1½ in. $16; 6 in. $161.52 plus. City furnishes all materials and labor. 6 in. tap costs between $100 and $150.

Gloversville—Cost.

Hempstead—½ in. tap $5.50; saddle $7.14; ¾ in. tap $7; 4⅝ in. tap $6; 1 in. tap $10.

Hudson—City makes and furnishes tap for $6.

Ithaca—½ in. tap $2.60; ¾ in. tap $2.75; 1 in. tap $3.

Jamestown—City makes no charge for tapping the main and bringing the service to the curb cock located at sidewalk line. This is furnished and installed by the municipality. Property owner carries the service into the building from the curb cock at his own expense.

Johnstown—When a permit is granted for water the city furnishes the service pipe, the curb cock and the corporation cock, does all the work including excavation, back fill-

ing and repaving and furnishes all material up to and including the curb cock box for the following charges: In unpaved streets, ½ in. tap, $18; ¾ in. tap, $21. In streets paved with cobble, macadam or bituminous macadam, ½ in. tap, $30; ¾ in. tap, $34. In streets paved with concrete or any pavement with a concrete foundation, ½ in. tap, $36; ¾ in. tap, $40.

Kenmore—If main is in the center of street, $5. If mains are on the side of street, $45. Note—The village lays on some streets, in fact on all new streets, mains on each side of street, and this $45 reimburses in part the cost of such additional expense, and agreed by all to the best for all concerned, doing away with the necessity of ripping up pavements for repairs.

If street is to be paved, all water mains are run in to the curb, and a charge of $29 is made, where sewer and water is laid in one trench, a charge of $5 is made.

Kingston—In order to insure the best material this department furnishes the tapping outfit to the licensed plumber for which he pays the sum of $10. This includes one ½ in. corporation cock and bend; one ¾ in. curb cock; one ¾ in. solder nipple; one No. 2 service box (curb). This department does the tapping, which is included in the above amount—we require ¾ in. AAA lead to be laid from the main to the curb line—this is also furnished by the consumer, also digging up and replacing pavement.

Long Beach—This is according to size and location under ordinary conditions the prices are as follows: ¾ in., $35; 1 in., $45; 1½ in., $65; 2 in., $75. Plus resurface charge on road openings. $1 per yard on brick roads; $3.50 per yard on asphalt and concrete.

Little Falls—½ in., $2.75; 1 in., $3.20, includes corporation cock, 2 in.-4 in., $18; 6 in., $22; 8 in., $26; 10 in., $30, does not include valve. The owner does excavation and replaces pavement at cost.

Lancaster—$1.

Mechanicsville—Property owner pays the plumber for all work after our inspection if satisfactory.

Mount Vernon—The tapping fees are as follows: ⅝ in., $8.10; ¾ in., $9.85; 1 in., $12.10. For this fee, the water department makes the tap on the main and inserts the corporation cock, and furnishes to the water consumer's plumber the quarter bend for wiping on to the lead service pipe, and the curb cock and the curb box. All excavations for the service line are made by the consumer's plumber.

Medina—All water service is made to curb by water company. From curb to residence by consumer.

Mamaroneck—None other than usual street opening permit charges. Mineola—$9 for each tap; $3 for each street opening.

Middletown—No charge.

Newark—Cost plus 10 per cent.

New Rochelle—Taps and service connection. When application is made for water the applicant shall report to the water company the name of a licensed plumber engaged to do his work. In case of each applicant the company reserves the right to name the size of tap to be inserted in the main. The service pipe from the main to the point where it enters private property will be furnished and owned by the water company, but the laying of the same and the balance of the service pipe, including all fixtures except the meter, shall be done to the satisfaction of the water company. All service pipes to be AA lead. The charge of tapping mains, and furnishing the necessary stop cocks, stop and waste cocks, and check valves which are essential to the safety and convenience of the consumer, will be as follows: ½ in., $10; ⅝ in., $12; 1 in., $18; 1¼ in., $21; 1½ in., $25; 2 in. or larger, $25. ⅝ in. AA lead service pipe to be connected to all ½ in. taps. ¾ in. AA lead service pipe to be connected to all ⅝ in. taps.

Niagara Falls—¾ in. connection, $2.50; 1 in. connection, $3. Consumer pays plumber to bring connection into property from tap on main. Larger size connections are made with sleeves and valves and the cost varies in accordance with amount of labor, etc.

Newburgh—The service pipe from main to the house is laid by the plumber. The curb faucet and curb box being furnished at cost ($8.75) by this department. A charge of $2.25 is made for furnishing corporation faucet and making the tap.

Norwich—We go to curb line only, remainder of pipe to cellar is at expense of property owner.

North Tonawanda—This is for the corporation only. Cocks only, the plumber puts in the service connections.

Oswego—$20 for ⅝ in. lead service; from main to curb in dirt streets, plumber has charge from curb to house. $30 when under paved streets.

Olean—As all work is done by contract prices vary.

Ogdensburg—In case of new service city puts in ¾ in. tap and pipe as far as sidewalk. Consumer stands expense from sidewalk to house. In case of renewal consumer stands expense of main to house, city standing expense of tap and connection at main and curb cock. Over ¾ in. consumer stands extra expense main to house in both new services and renewals. Our paved streets have services laid to vacant lots. Where we break pavements for fire service, etc., consumer stands expense. ¾ in. pipe and trenching ordinary macadam streets per foot, $0.95; 1 in. pipe and trenching, $1; 1¼ in. pipe and trenching, $1.05; 1½ in. pipe and trenching, $1.10; 2 in. pipe and trenching, $1.15.

Penn Yan—$1 for tap and property owner pay all other expenses.

Port Chester—Brick paving, 60 ct. sq. ft.; concrete paving, 60 ct. sq. ft.; wood paving, 60 ct. sq. ft.; macadam, 40 ct. sq. ft.; dirt road, $5; asphalt block, 60 ct. sq. ft.

Port Jervis—This is a privately owned plant. Consumers are obliged to pay for all water taps and service connection. The total charge varies according to the size of service desired by the applicant and the width of the street in which it is installed. Our rates are as follows, for ½ in. AA lead service:

1—½ in. corporation cock and tapping	$4.50
1—½ in. curb cock, curb box and rod	6.50
Service charge per foot	1.20
for ⅝ in. AA Lead Service	
1—⅝ in. corporation cock and tapping	5.00
1—⅝ in. curb cock, curb box and rod	7.00
Service charge per foot	1.20
for ¾ in. AA Lead Service	
1—¾ in. corporation cock and tapping	5.50
1—¾ in. curb cock, curb box and rod	8.00
Service charge per foot	1.30
for 1 in. AA Lead Service	
1— 1 in. corporation cock and tapping	7.00
1— 1 in. curb cock, curb box and rod	9.50
Service charge per foot	1.50

The above charges include all common labor and service of plumber making the installation. In case the service is installed in a paved street the additional labor necessary in making the necessary opening through the pavement is charged for in addition to the regular installation charge as per above schedule.

Rensselaer—The company does the work and the consumer pays for same as follows: ⅝ in. tap, including lead connection, curb stop and box, $9; ¾ in. tap, including lead connection, curb stop and box, $10; 1 in. tap, including lead connections, curb stop and box, $12.

Rochville Centre—$2.50 each.

Rye—$2.60 for ⅝ in. tap and $26.50 for ¾ in. (This does not include making repairs to the street.) For macadam repairs the village charges 50 ct. per sq. ft. and for Hasting block 80 ct. per sq. ft.

Rochester—Charge is made for the tap—according to size—including insertion in main. Types of street not considered by the bureau at all. The plumber makes bargain with the owner for the whole job.

Scotia—$10.

Schenectady—½ in. tap, $70; ¾ in. tap, $9; 1 in. tap, $11. The street department makes a charge of $10 for the first sq. yd. of asphalt, etc., cut and an additional charge of $3 for each yard thereafter. This is in addition to charge made for tapping.

Sherrill—District taps main—no charge and furnished curb box, corporation cock. Consumer lays all connections. We allow to consumer who is on far side of the street an upset figure for approximately twice the distance from main to center of street, thus putting on same lead as the near consumer who gets no allowance toward cost of his connection. Consumer pays for meter also. Our upset figure is $0.65 a foot for all sorts of road or pavement. We used to have a price for each sort, but treat all as costing at least $0.66. Probably most cases cost actually more than we allow.

Saratoga—⅝ in. tap, $6; ¾ in. tap, $8; 1 in. tap, $10.

Salamanca—Consumer pays for all connections to the main, also pays for all damage to street. If leak develops on consumer's line he is notified to have same repaired; if it is not taken care of, water department opens up street and shuts off water, and water is not turned on until necessary repairs are made and bill paid for opening up street and shutting off water.

Scarsdale—¾ in. tap, $10; 1 in. tap, $12; 1¼ in. tap, $20; 1½ in. tap, $28; 2 in. tap, $35.

Tonawanda—$4 for ⅝ in. tap (made by city); 33 ct. a foot for ⅝ AA lead pipe; $2.50 for curb box; $2 for curb cock. The lead, curb box and curb cock are sold by the city to the plumber doing the work, the tap is also charged to plumber, who charges same to consumer.

Tarrytown—¾ in. tap at $3.20 each; 1 in. tap at $4 each; larger taps or tee connections at cost.

Troy—¾ in. corporation cock, curb cock, curb box tapping, $14.25; 1 in. corporation cock, curb cock, curb box, tapping, $17.35; 1¼ in. corporation cock, curb cock, curb box, tapping, $27.50; 1½ in. corporation cock, curb cock, curb box, tapping, $36.50; 2 in. corporation cock, curb cock, curb box, tapping, $49.50. Labor and lead pipe are extra.

Valley Stream—This village has no municipal water supply. Water supplied by a private corporation. The municipality charges $2.50 for each street opening on dirt surface roads, the plumber who makes application for the permit paying the fee. The paved roads have just been laid, and no openings will be permitted for six months.

Watertown—$20 for ¾ in. connection; $25 for 1 in. connection; above 1 in. is put in at cost. In addition to the above charge, there is always an additional charge for replacing the pavement, which varies from 50 ct. to $5 per sq. yd.

New York—Schedule of charges for furnishing and installing wet connections:

Pipe in.	Size of Connection in.	Total Cost Minus Valve Box	Total Cost of Valve Box and Cover	Total Cost
4	2	$ 34.50	.....	$34.50
6	2	38.25	.....	38.25
6	3	43.00	.....	43.00
6	4	48.00	$10.25	58.25
8	2	41.75	.....	41.75
8	3	47.25	.....	47.25
8	4	53.50	10.25	63.75
8	6	75.25	10.25	85.50
10	2	46.75	.....	46.75
10	3	53.25	.....	53.25
10	4	59.25	10.25	69.50
10	6	82.23	10.25	92.50
10	8	108.75	10.25	119.00
12	2	53.00	.....	53.00
12	3	58.25	.....	58.25
12	4	64.75	10.25	75.00
12	6	87.25	10.25	97.50
12	8	115.75	10.25	126.00
14	2	61.75	.....	61.75
14	3	66.75	.....	66.75
14	4	78.25	10.25	98.00
14	6	104.75	10.25	115.00
14	8	136.25	10.25	148.50
16	2	68.25	.....	68.25
16	3	75.75	.....	75.75
16	4	82.50	10.25	92.75
16	6	110.00	10.25	120.25
16	8	138.75	10.25	149.00
16	12	207.50	10.25	217.75
20	2	82.75	.....	82.75
20	3	87.75	.....	87.75
20	4	99.75	10.25	110.00
20	6	125.50	10.25	136.75
20	8	159.25	10.25	169.50
20	12	237.50	10.25	247.75
24	2	109.25	.....	109.25
24	4	128.00	10.25	138.25
24	6	154.00	10.25	164.25
24	8	199.00	10.25	209.25
24	12	302.50	10.25	312.75
30	2	127.00	.....	127.00
30	4	143.75	10.25	154.00
30	6	198.25	10.25	202.50
30	8	229.75	10.25	240.00
30	12	313.75	10.25	324.00
36	2	183.50	.....	183.50
36	4	201.50	10.25	211.75
36	6	234.25	10.25	244.50
36	8	275.50	10.25	285.75
36	12	373.00	10.25	383.25
48	6	382.25	10.25	392.50
48	8	439.50	10.25	449.75
48	12	609.50	10.25	619.75
48	20	962.50	10.25	972.75

The following is a list of the charges for

Screw Taps

⅝ in.	$ 4.50
¾ in.	5.00
1 in.	6.00
1½ in.	12.00
2 in. on 12 in. main	15.00

Yonkers—Furnish and tap main, tap has coupling for lead pipe, furnished by city. Cost of plumber, ⅝ in. tap, $6; cost of plumber, ¾ in. tap, $7; cost of plumber, 1 in. tap, $9; cost of plumber, 1½ in. tap, $17; cost of plumber, 2 in. tap, $27. Larger sizes we have a deposit made to cover cost of same. Charges for street openings are regulated as to kind of pavement. $50 granite rock; $40 asphalt; $40 penetration; $5 macadam.

Malone—The water department makes the tap, furnishes the shut off, curb cock and curb box, after the consumer has the excavating done.

Saranac Lake—Consumer pays for all material—opens and fills the trench—the board makes the tap and installs the brass connections. The municipality furnishes pipe and labor to lay private connection from main to curb.

East Rochester—Labor and material at cost.

Syracuse—Where application for service is made on a paved street the owner of property is required to make a deposit to cover the cost of repairs to pavement. After repairing pavement refund is made for the difference of the deposit and cost of repair. This is the only charge on services where water is put in. Fire services are laid by the bureau of water and entire cost is paid for by the property owner, as there is no charge for water used on fire services as they are used only in case of fire.

Waverly—$7.

Rates Paid by Large Cities for Water for Municipal Purposes

The following information on the above subject was taken from *Municipal News and Water Works:*

Questionnaires were sent to the 33 cities of over 200,000 population in this country.

The following cities report some payment from the city:

Akron—"Small amount annually."

Buffalo—Four cents per 1,000 gal. (1924 information). No hydrant rental.

Denver—"Some departments supplied free, others at reduced rates."

Indianapolis (private company)—Rate not given. Water for hydrants supplied on inch-foot basis with nominal annual rental.

Milwaukee—Regular rates. Hydrant rental $10 per year per hydrant.

Minneapolis—Free water for general city service. Parks and libraries pay 4 ct. per 100 gal.

Oakland (private company)—Regular rates for metered service. Public use charge based on number of feet of streets piped and number of hydrants: $10 to $50 per year per 1,000 ft. piped according to size of main, and $8 to $10 per hydrant per year if owned by the company, or $3 to $5 if owned by city. Basic charge for public use in 1917 was $105,500.

Omaha—No charge for city buildings or for flushing streets. All water used for sanitary sewer systems in excess of 50,000 gal. per flush tank per month charged for at regular rates. Hydrants $60 per year.

Philadelphia—Schools and charitable institutions, 6 ct. per 1,000 cu. ft.

Pittsburgh—Public buildings at hotel rates. Charitable institutions and schools have free allowance, then 7 ct. per 1,000 gal. (1924 information).

Portland—$75,000 per year.

Providence—Most municipal supplies pay regular rates. No hydrant charge (1924 information).

Rochester—$150,000 per year.

St. Louis—Schools and libraries, 6 ct. per 100 cu. ft. Charitable institutions, 4½ ct. per 100 cu. ft. No hydrant charge.

St. Paul—Regular rates. Hydrant charge $14 per year per hydrant.

San Francisco (private company)—Regular rates. Hydrants, $5 per month per hydrant.

Seattle—For flushing streets, $14,400; for hydrants, $9 per year per hydrant.

The remaining cities considered in the compilation report no charge for water supplied for municipal purposes.

Jersey City has a book charge of $75,000 a year. In Detroit hydrants are furnished and maintained by the fire department. No recent information has been received for Atlanta, Boston, Jersey City or New Orleans. These cities in 1924 reported free water.

No information is available for Baltimore.

GEORGE H. SNELL COMPANY

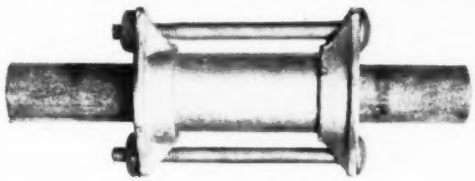
Attleboro, Massachusetts

Manufacturers of Threadless Pipe Couplings and Tees

Products: SNELL THREADLESS PIPE COUPLINGS AND TEES FOR WATER PIPES, COMPRESSED AIR LINES, MINE WATER AIR LINES, PLUMBERS' SERVICE CONNECTIONS AND METER CONNECTIONS.

Snell's Couplings and Tees have been used extensively in the above fields for over a quarter of a century, giving absolute satisfaction.

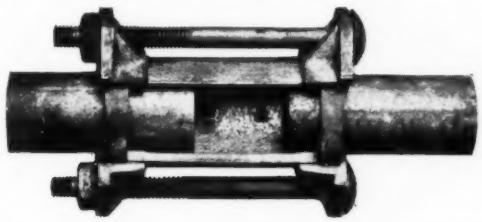
Snell's Couplings and Tees are Threadless. No pipe threading required. Guaranteed to stand the strain of 250 lbs. pressure. Forms a perfect expansion joint for overcoming



electrolysis. All pipe lines, particularly those carrying water and gas, should be Snell Coupled. Regardless of what kinds of pipe you are using we believe, considering first cost, general efficiency, low maintenance expenses and other factors entering into the construction and operation of Water and Gas Lines, a Snell Coupled Line will give more service per dollar than any other.

As a pipe line, like a chain, is no stronger than its weakest link or joint, it behooves one to purchase the best coupling the market affords. Snell couplings combine flexibility with strength which care for expansion and contraction as well as settling ground.

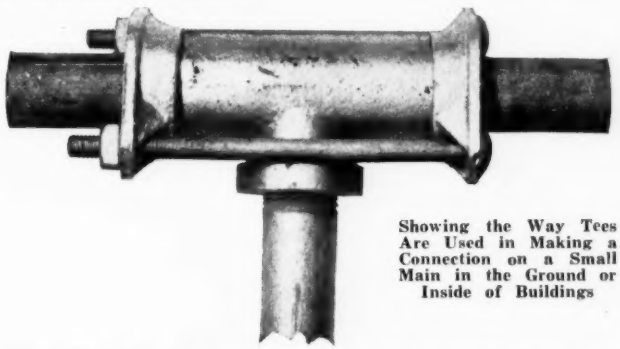
Installing Couplings and Tees: The Snell Easy On Threadless Couplings and Tees are rightly named. There are only



two bolts, pipe does not have to be in alignment, no threads to cut or screw up, and a tight connection guaranteed, very little pressure on the bolts to make a permanent, lasting connection.

For Making Repairs: Using Snell Couplings and Tees saves cutting threads in trenches, and using unions, does not require so large a trench and pipe does not have to be in line. Can be put on under water when necessary and repairs can be made when ordinarily would be impossible to use any other fitting, thereby saving entirely new construction.

Make-Up of Snell Couplings and Tees: Ends—Grey Iron Castings. Barrels—Seamless Steel Tubing. Rubber Gaskets—Special Compound for both Water and Gas. Bolts—Coppered and Nickeled. Combined with our process of hot galvanizing over all in making the Snell Couplings and Tees is your solution in reducing your pipe line troubles to an absolute minimum.



Showing the Way Tees Are Used in Making a Connection on a Small Main in the Ground or Inside of Buildings

Durability of the Rubber Gasket: (Also made in Brass). Owing to the manner in which the rubber is compressed in the recess of the flange, and against the barrel of the coupling, also the pipe, it is practically hermetically sealed. The perfect compression makes it impossible for any deterioration to take place, and consequently will last as long as the pipe itself.

TEES

Sizes	Over All Length	Weight	Sizes	Over All Length	Weight
½x½x½	4¾ ins.	1 lb. 4 oz.	2x2x¾	8 in.	7 lb. 8 oz.
¾x¾x¾	5 "	1 " 12 "	2x2x1	9 "	7 " 8 "
1x1x¾	6 "	2 " 10 "	2x2x1¼	9 "	7 " 10 "
1x1x1	6 "	2 " 14 "	2x2x1½	9 "	7 " 12 "
1¼x1¼x¾	7 "	4 "	2x2x2	9 "	8 "
1¼x1¼x1	7 "	4 "	2½x2½x2	12 "	16 " 4 "
1¼x1¼x1¼	7 "	4 " 8 oz.	2½x2½x2½	12 "	17 " 8 "
1½x1½x¾	7½ "	4 " 14 "	3x3x2	14 "	23 " 8 "
1½x1½x1	7½ "	4 " 14 "	3x3x3	14 "	24 " 12 "
1½x1½x1¼	7½ "	5 " 4 "	4x4x2	15 "	29 "
1½x1½x1½	7½ "	5 " 6 "	4x4x3	15 "	30 "
			4x4x4	15 "	31 " 8 "

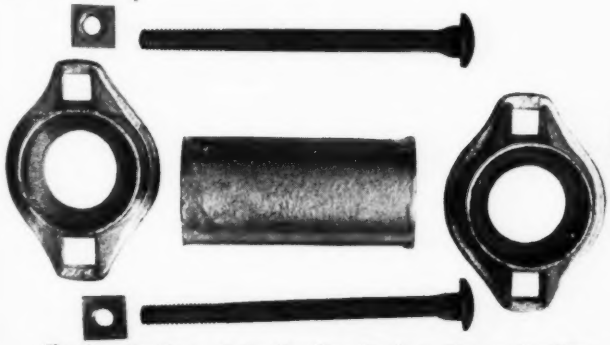
COUPLINGS

Sizes	Length	Weight	Sizes	Length	Weight
½	3¾ in.	1 lb.	2	6 in.	4 lb. 10 oz.
¾	3⅞ "	1 " 6 oz.	2½	11¼ "	14 "
1	4⅜ "	2 " 4 "	3	14 "	20 "
1¼	5 "	2 " 12 "	4	14 "	23 "
1½	6 "	3 " 12 "	6 in.	13 "	40 "
			8 in.	13 "	77 "

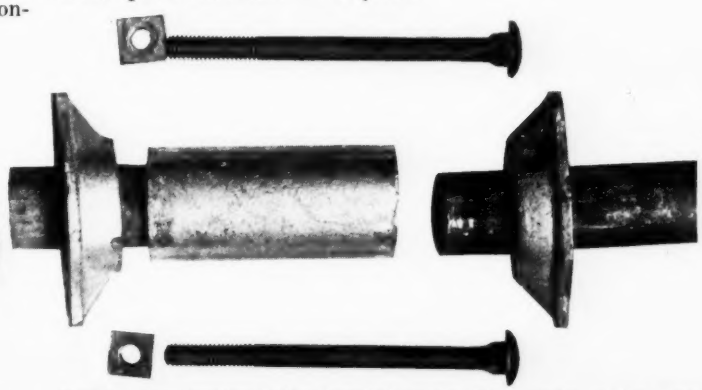
For McWane C. I. Pipe: 1¼ in., 2 in., 1¼x1¼x1 Tee, 2x2x1 in. Tee.

Prices on Larger Sizes upon application. In Brass, prices slightly higher.

Descriptive literature on request.



Showing the Parts of the Coupling Ready to Put on the Pipe



Showing the Coupling Being Installed on the Pipe, Ready to Slip Over the Opening and Be Bolted Together

Compressed Air Terms

Nomenclature and Terminology

From the Standards of The Compressed Air Society

In the advances made in the use of compressed air many terms and expressions have been adopted and it is felt necessary for a complete and thorough understanding of compressors and the uses of compressed air that these terms be clearly defined.

Compressors.—A compressor is a machine designed for compressing air or gas from an initial intake pressure to a higher discharge pressure. Machines built for accomplishing this work are made in various styles or classes.

Turbo, Rotary and Centrifugal Compressors.—These are machines in which the compressing element is of the rotating construction.

Reciprocating Compressors.—These are machines in which the compressing element is of the reciprocating construction.

The following definitions apply to reciprocating compressors:

Vertical Compressors.—A vertical compressor has the compressing element in a vertical position.

Horizontal Compressors.—A horizontal compressor has the compressing element in a horizontal position.

Angle Compressors.—An angle compressor is of the multi-cylinder type with part of the compressing element located horizontally and part of the compressing element located vertically.

Straight Line Compressors.—In this class of machine the driving and compressing elements are placed in a horizontal position and in line with one another.

Duplex Compressors.—Duplex compressors consist of two straight line units placed parallel on one common crank shaft.

Single Acting Compressors.—A single acting compressor consists of one or more compressing units, the compression taking place on but one stroke per revolution in each compressing element.

Double Acting Compressors.—A double acting compressor consists of one or more compressing units, the compression taking place on both strokes per revolution in each compressing element.

Single Stage Compressors.—When air or gas is compressed in each cylinder from initial intake pressure to final discharge pressure on each working stroke of the piston the machines are said to be of the single stage type.

Two-Stage and Multi-Stage Compressors. When air or gas is compressed from initial intake pressure to final discharge pressure in two distinct steps, the machine is said to be of the two-stage type.

More than two distinct steps can be used in compressing air or gas to its final pressure, and machines so constructed are spoken of as multi-stage machines, or as three or four stage machines, depending on the number of distinct compressing stages.

Air Cooled Compressors. Air cooled compressors are those machines having radiating fins cast on the cylinder walls and in which the cooling of the compressor cylinder is obtained through the circulation of atmospheric air around the compressor cylinder.

Water Cooled Compressors. Water cooled compressors are machines in which the compressor cylinders are colled by the circulation of water through jacketed spaces adjacent to the cylinder.

Hopper Jacketed Compressors. Hopper jacketed compressors are constructed so that the jacketed space around the compressor cylinder forms an open reservoir to be filled with cooling water.

Portable Compressors. A portable compressor is a complete air compressor plant consisting of compressor, prime mover and air receiver all mounted on a chassis so that it may be readily moved.

Semi-Portable Compressors. A semi-portable compressor is a complete machine skidded or, one that can be moved about from place to place but not on its own wheel base.

Intercooler. A device for removing the heat of compression between the stages of compression on compound or multiple stage compressors.

Inlet Valve. A device for admitting air or gas into the cylinder and to prevent its return when being compressed.

Discharge Valve. A device for permitting the discharge of compressed air or gas from the compressor cylinder and to prevent its return to the cylinder.

Air Receiver. A receptacle into which the compressed air or gas is discharged from the compressor. A receiver helps to eliminate pulsations in the discharge line. It also acts as storage capacity during intervals when the demand exceeds the capacity of the compressor.

Moisture Trap. A means for collecting and removing moisture, precipitated from the air or gas during the process of cooling.

Aftercooler. A means for reducing the heat of compression generated in the final stage of compression and also one of the most effective methods of removing moisture from compressed air.

Reheater. A means for raising the temperature of compressed air.

Air Filters. An air filter as used on compressors is a device for removing the small particles of dust and dirt from the air going into the machine.

Standardizing Hand of Compressor. To avoid misunderstandings it is recommended that the following be observed in determining the right or left hand side of a compressor:

Standing at the air cylinders of a duplex machine and looking toward the power end, the frame to the right is designated as the right hand side and the one to the left is designated as the left hand side.

Identifying Cylinder Heads. The head of an air cylinder next to the frame is designated as "the frame end cylinder head." The head at the other end of an air cylinder is designated as "the outer cylinder head."

Definitions

From the Trade Standards of The Compressed Air Society

Absolute Temperature. Absolute temperature on Fahrenheit scale is the reading of the thermometer in degrees Fahrenheit plus 459.6 degrees.

Absolute temperature on Centigrade scale is the reading of the thermometer in degrees Centigrade plus 273 degrees.

Isothermal Compression. That case of compression where the gas does not change in temperature during compression. Compression curve follows Boyle's law that $PV = P_1V_1$ or $PV = K$ where P = absolute pressure; V = volume of gas present; K = constant.

Adiabatic Compression. That case of compression where during compression the temperature of the gas can rise unchecked, namely, where there is no transfer of heat to or from the fluid being compressed.

The equation of the adiabatic compression curve is $PV^n = K$, where P = absolute pressure; V = volume of gas present; K = constant; n = coefficient; the ratio of specific heat at constant pressure to specific heat at constant volume. For air it is 1.406 (usually expressed as 1.41).

Displacement. The displacement of a compressor is the volume displaced by the net area of the compressor piston multiplied by the length of stroke and by the number of strokes per minute. For compound and multi-stage machines only the low pressure cylinder is considered.

Free Air. By free air is meant air at normal atmospheric conditions. Because the altitude, barometer and temperature vary at different localities, it follows that this term does not mean air under identical conditions.

Considerable confusion has existed regarding the term "free air" and it has been interpreted to be air at sea level conditions, namely, at an absolute pressure of 14.7 pounds per square inch and at a temperature of 60 degrees Fahrenheit. We feel that this is not the correct interpretation of the expression "free air," and that "free air" is the normal atmospheric condition of the air at the point where the compressor is installed.

Capacity (Actual). The capacity of an air or gas compressor is the actual amount of air or gas compressed and delivered, expressed in cubic feet per minute at intake temperature and pressure. The delivery measurement to be as actually made by low pressure orifice test.

Volumetric Efficiency. The volumetric efficiency is the ratio of the capacity of the compressor to displacement.

Compression Efficiency. Compression efficiency is the ratio of the theoretical power required to compress the

amount of air or gas actually delivered to the actual power required in the compressor cylinder as shown by indicator diagrams.

The theoretical power may be calculated according to the isothermal base, or according to the adiabatic base, and the compression efficiency correspondingly defined.

Mechanical Efficiency. Mechanical efficiency is the ratio of the air indicated horsepower to the indicated horsepower in the power cylinders, in the case of steam driven or internal combustion engine driven compressors, and to the brake horsepower delivered to the shaft in case of a power driven machine.

Overall Efficiency. The overall efficiency is the product of the compression efficiency and the mechanical efficiency.

Load Factor. The load factor is the ratio of the average compressor load during a certain period of time to the maximum rated load of the machine.

Low Pressure Orifice Test.—A method of accurately measuring the air delivered by a compressor. The method of conducting a low pressure orifice test is given in section three, with the terms used.

Formulas for Pumps and Piping

From the Mining Catalog

TO FIND:	GIVEN:	FORMULAS:
1. Pressure in lb. per sq. in.=P.	Head in ft.=H.	$P=H\times 0.433.$
2. Head in feet=H.	Pressure in lb. per sq. in.=P.	$H=P\times 2.312.$
3. Horse power required to raise water (theoretical).	Gallons per Min.=G. Head in ft.=H.	$HP=\frac{G\times H}{33{,}000}$
4. Volume of water discharged by pipe (neglecting bends and friction).	Internal dia. of pipe in inches=D. Head in ft.=H. Length of pipe in yd.=L.	Gal. per min.$=\sqrt{\frac{D^5\times H}{L}}$
5. Theoretical capacity of single acting pump.	Area of ram in square inches=A. Stroke in inches=S. No. of strokes per min.=N.	Gal. per min.$=\frac{A\times S\times N\times 62.5}{1728}$
6. Diam. in inches of single acting pump to deliver given number of gals. per stroke.	Gal. per stroke=G. Stroke in ft.=S.	Dia. of pump$=\sqrt{\frac{31\ G}{S}}$ (Allowing 5% waste.)
7. Feet head lost by friction in pipes=F.	Gal. per min.=G. Length of pipe in yd.=L. Internal diam. of pipe in in.=D.	$F=\frac{G^2\times L}{(3\ D^5)}$
8. Approx. weight of water in vertical pipes in lb.=W.	Internal diam. of pipe in in.=D. Length of pipe in yd.=L.	$W=D^2\times L$
9. Thickness of cast iron pipes in inches=T.	Internal diam. of pipe in in.=D. Pressure in lb. per sq. in.=P.	$T=\frac{D\times P}{4000}+0.3$
10. Delivery per stroke of single acting pump.	Diam. of plunger in in.=D. Stroke in ft.=S.	Gal. delivered per stroke$=\frac{D^2\times S}{31}$ (Allowing 5% waste.)
11. Speed of water through pipes in ft. per sec.	Area of pipe in sq. in.=A. Discharge in cu. ft. per min.=F.P.M.	Velocity ft. per sec.$=\frac{FPM\times 2.4}{A}$
12. Velocity in ft. per sec. due to head=V.	H=Head. g=32.2 Gravity.	$V=\sqrt{2gH}$
13. Head from velocity.	.....	$H=\frac{V^2}{2g}$
14. Imperial gallons.	Cubic feet=C.	Imperial gallons=C×62.5
15. Cubic feet.	Gallons (Imperial)=G.	Cubic feet=G×0.16

SCHRAMM, INC.

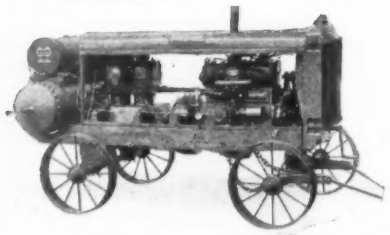
West Chester, Pa.

Manufacturers of Air Compressors

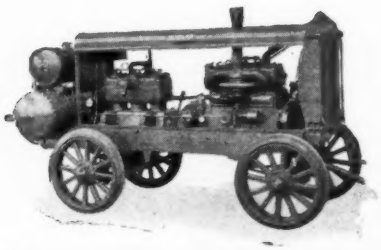
New York Philadelphia Pittsburgh Chicago Tulsa San Francisco

Representatives in All Principal Cities

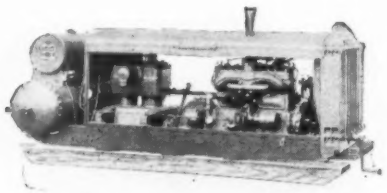
Products: AIR COMPRESSORS.



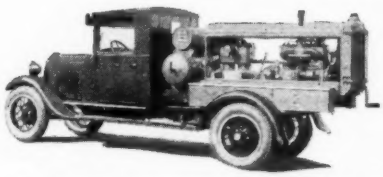
"Schramm" Multi-Cylinder Air Compressor on Standard Steel Wheel Truck



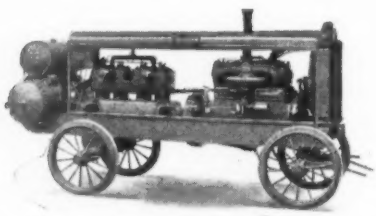
"Schramm" Multi-Cylinder Air Compressor on Spring Equipped Artillery Wheel Trailer



"Schramm" Multi-Cylinder Air Compressor on Wooden Skids

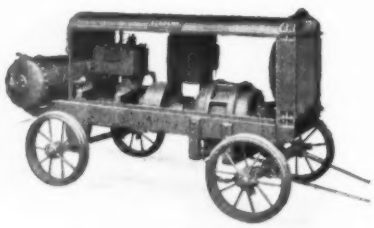


"Schramm" Engine Driven Compressor for Mounting on Various Type Motor Trucks

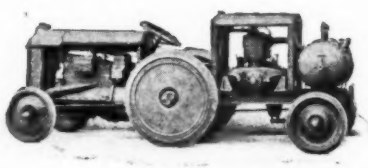


"Schramm" Multi-Cylinder Air Compressor on Rubber Tire Steel Spoke Wheels

"Schramm" Multi-Cylinder Air Compressor with Side Doors in Place



"Schramm" Direct-Connected Motor Driven Portable Compressor



"Schramm" Compressor Tractor Combination

SCHRAMM Multi-Cylinder Portable Air Compressors are built in sizes of 60, 120, 180, 240 and 360 cu. ft. displacement per minute.

Gasoline operated compressors are equipped with heavy duty BUDA engines. The SCHRAMM clutch, a distinctive SCHRAMM feature, installed between engine and compressor permits starting of engine independent of the compressor. All sizes, with exception of 60 cu. ft. are mounted on one piece cast steel frames. The special "SCHRAMM" slow-down governing device automatically cuts engine speed to a minimum as soon as compressor unloads, thereby saving much fuel and wear.

These same compressors may be had for electric motor drive.

SCHRAMM compressors may be had on steel wheels, rubber tires, or the SCHRAMM spring equipped trailer. In addition the units may be obtained skidded for semi-portable installations, or for mounting on standard automobile truck chassis.

SCHRAMM compressors for attaching to the Fordson, or the McCormick-Deering tractors are furnished in sizes ranging from 60 to 160 cu. ft.

Send for complete Catalog.

SULLIVAN MACHINERY COMPANY

ESTABLISHED 1850

830 Wrigley Bldg., Chicago, Ill.

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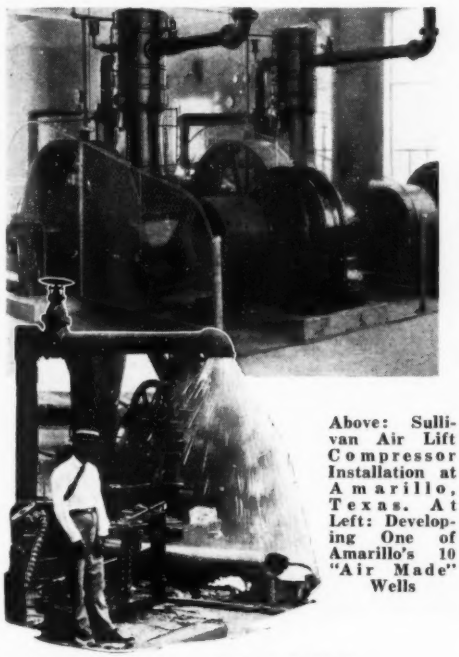
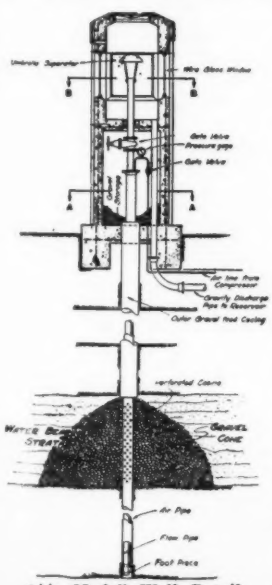


Above: Sullivan Air Lift Compressor Installation at Amarillo, Texas. At Left: Developing One of Amarillo's 10 "Air Made" Wells

Sullivan Air Lift Water Supply: For municipal water supply, Air Lift has several important advantages over mechanical pumping systems. There are no moving parts in the well and consequently no trouble is experienced from mud or sand, crooked wells, or varying water levels. As the power for pumping the water is supplied by Sullivan Air Compressors, the entire system is economical and trouble-free. **Catalog 8481-I.**

Automatic Air Lift: Sullivan Air Lift, completely automatic systems, have been installed in many instances. Air Lift delivers water to ground level, from where it is lifted to mains or elevated tank by a centrifugal pump. A float switch starts and stops the compressor and pump automatically.

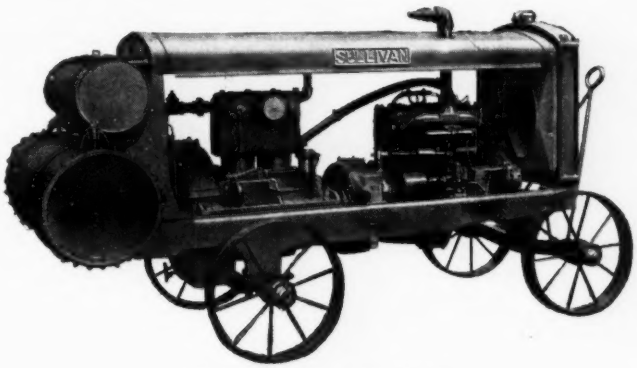


"Air Made" Well Detail

"Air Made" Wells: Nearly everyone has heard about "Air Made" Wells, and how they have given many districts permanent dependable water supply systems. But the full significance of this new development, is not always grasped. Where a municipality must depend on shallow sand strata for water, the "Air Made" Well is indispensable, as it furnishes the only means of securing a permanent, undiminishing supply.

But where both shallow sand and deep rock sources of water are available, the "Air Made" Well saves the cost of lifting water from great depths. **See Catalog 8456-J.**

Sullivan Portable Air Compressors: With trench digging, and pipe laying, and repairing being speeded up everywhere with Air Power, a trouble-free portable air compressor like the Sullivan "Vibrationless" machine, offers you an exceptionally profitable investment.



110-Ft. Portable Compressor

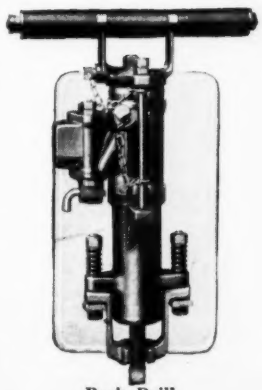
Sullivan "Vibrationless" Compressors run so smoothly that a glass of water filled to the brim will stand on the frame of the machine, running under full speed and load. This is due to perfect static and dynamic balance, to harmony of power impulses with load demands, to flywheels on both engine and compressor, and to four "balanced-V" cylinders on the big models.

Concrete Breaker

Clay Spader

Sullivan Compressors are available in capacities of 103, 110, 160, 206, 220, and 310 cu. ft. sizes; on steel wheels, trailer trucks, or on skids ready for mounting on your own truck; and with gasoline engines, or electric motors. **Catalog 8483-F.**

Sullivan Air Tools: Sullivan Rock Drills, Concrete Breakers, and Clay Spaders are furnished in numerous models, to speed up trench digging and pipe laying and repairing. Send for the picture book "Speed Up With Air."



Rock Drill

Sullivan Portable Hoists: Sullivan 345 lb. hoists will lift a ton on single line, or pull a 50 ton car on level track. They are dependable machines which will save you time and money in handling pipe, well casing, and other equipment. **Catalogs 8476-F, 8476-G.**

Pumps

Definitions and Values

Adopted by The Hydraulic Society

Efficiency, Hydraulic (Symbol e_h).—The ratio of the useful power delivered in the water at the point of discharge where measured to the power delivered to the water by the impeller at the point of exit from the impeller.

Efficiency, Mechanical (Symbol e_m).—The ratio of the water horsepower to the horsepower required to drive the pump.

Efficiency, Overall (Symbol e).—Comprises all the losses in the pump and the driver, and indicates the economy of the entire unit.

Head, Total Dynamic (Symbol T.D.H.).—Total dynamic head is the vertical distance between the source of supply and point of discharge when pumping required capacity, plus friction entrance and exit losses.

Total dynamic head, as determined on test, where suction lift exists, is the reading of a mercury column connected to the suction nozzle of pump, plus the reading of a pressure gauge connected to discharge nozzle of pump, plus vertical distance between point of attachment of mercury column and center of gauge, plus excess, if any, of velocity head of discharge over velocity head of suction as measured at points where the instruments are attached, plus head of water resting on mercury column, if any.

Total dynamic head, as determined on test, where suction head exists, is the reading of a gauge attached to the discharge nozzle of pump, minus the reading gauge connected to the suction nozzle of pump, plus or minus vertical distance between centers of gauges (depending on whether suction gauge is below or above discharge gauge) plus excess, if any, of velocity head of discharge over velocity head of suction as measured at points where instruments are attached.

Total Dynamic Discharge Head is the total dynamic head minus dynamic suction lift, or plus dynamic suction head.

Head, Static (Symbol H_s).—Static head is the vertical distance between the free level of the source of supply and to the point of free discharge, or to the level of the free surface of the discharge water.

Head, Velocity (Symbol H_v).—The velocity head (sometimes called "Head due to Velocity"), of water moving with a given velocity, is the equivalent head through which it would have to fall to acquire the same velocity; or, in other words, the head necessary merely to accelerate the water. Knowing the velocity, we can readily figure the velocity head from the simple formula:

$$h = \frac{V^2}{2g}$$

in which "g" is acceleration due to gravity, or 32.16 feet per second; or, knowing the head, we can transpose the formula to:

$V = \sqrt{2gh}$, and thus obtain the velocity.

The velocity head is a factor both in figuring the total head from construction data and testing.

When estimating the total dynamic head of an installation, the head equivalent to the velocity of the water leaving the end of the discharge pipe line must be added to the static and friction head.

When testing a pump, certain velocity head corrections must be made, depending on the average velocity at the point where pressure readings are taken. The customary method of testing is to use a mercury column for obtaining the suction lift and a gauge to indicate the discharge or suction head, with gauge connections at or close to the pump openings.

The mercury column at the suction will show the dynamic suction head at the point of gauge connection. Included in this dynamic suction head is the velocity head as represented by the average velocity at that point.

The discharge gauge will show the dynamic pressure head at the point of gauge connection.

The sum of the two gauge readings, corrected to the same elevation will give the total dynamic head produced by the pump provided water flows at the same average velocity at the point of attachment of suction gauge as of discharge gauge. This condition will exist when suction and discharge openings are of equal size.

If the discharge pipe is of smaller diameter than the suction pipe, which is often the case, then it will be necessary to add to the total head, as shown by the gauges, the difference in velocity head between that of the discharge and that of the suction pipe at the point where gauges are connected.

If the discharge pipe is larger than the suction pipe, the difference in velocity head must be subtracted from the total head.

Velocity ft. per second	1	2	3	4	5	6	7
Velocity head in ft.	.02	.06	.14	.25	.39	.56	.76
Velocity ft. per second	8	8.5	9	9.5	10	10.5	
Velocity head in ft.	1.0	1.12	1.25	1.4	1.55	1.7	
Velocity ft. per second	11	11.5	12	13	14	15	
Velocity head in ft.	1.87	2.05	2.24	2.62	3.05	3.5	

Horsepower, Brake (Symbol b-hp.).—The actual horsepower required at the pump shaft to drive the pump = $\frac{\text{w-hp}}{e_m}$. Brake horsepower is not applicable to direct-acting steam pumps.

Horsepower, Indicated (Symbol i-hp.).—The horsepower developed in the steam or liquid end calculated from indicator cards.

Suction Head (sometimes called head on suction) exists when the pressure measured at the suction nozzle and corrected to the center line of the pump is above atmospheric pressure.

Suction Head Dynamic, where static suction head exists, is the vertical distance from the source of supply, when pumping at required capacity, to center of pump, minus velocity head, minus entrance, friction and velocity losses; but not minus internal pump losses.

Suction head dynamic, as determined on test, is the reading of a gauge connected to suction nozzle of pump, minus vertical distance from center of gauge to center line of pump. Suction head, after deducting the various losses, may be a negative quantity, in which case a condition equivalent to suction lift will prevail.

Suction Head Static exists when the source of supply is above the center of pump and is the vertical distance from the free level of the source of supply to center of pump.

Suction Lift.—Suction lift exists when the suction measured at the pump nozzle and corrected to the center line of the pump is below atmospheric pressure.

Suction Lift Dynamic, where static suction lift exists, is the vertical distance from the source of supply, when pumping required capacity, to center of pump, plus velocity head, plus entrance, friction and velocity losses, but not including internal pump losses; where static suction head exists but where the losses exceed the static suction head the dynamic suction lift is the sum of the velocity head, entrance, friction and velocity losses, **minus** the static suction head, but not including internal pump losses.

Suction lift dynamic, as determined on test, is the reading of a mercury column connected to suction nozzle of pump, plus vertical distance between point of attachment of mercury column to center of pump, plus head of water resting on mercury column, if any.

Suction Lift Static exists when the source of supply is below the center of pump and is the vertical distance from the free level of source of supply to center of pump.

Viscosity is that property of a liquid which resists any force tending to produce flow. Viscosity is a property independent of specific gravity.

Prime Movers

Definitions and Values

Extracts from the American Society of Mechanical Engineers' Power Test Codes, 1923. Approved Dec. 1, 1924, and Subject to Revision. Taken from Standards of Hydraulic Society

Atmosphere (Symbol atmos.).—760 mm. mercury at ice point and standard gravity = 14.7 lb. at sea level.

British Thermal Unit (Symbol B.t.u.).—1/180 of the heat required to raise 1 lb. mass of water from the ice point to the steam point under constant pressure of 1 atmosphere.

Efficiency, Cycle (Symbol e_c).—Cycle efficiency is the ratio of heat available for conversion into work to the total heat supplied. This efficiency is often referred to as the efficiency of the ideal engine.

Efficiency, Engine (Symbol e_e).—Engine efficiency is the ratio of heat converted to work in the actual engine to the heat available for conversion to work by the cycle employed, or it is equivalent to the actual work done by the engine, divided by the work which could be done by a perfect engine on the same cycle. Engine efficiency is usually determined from a measured thermal efficiency and a calculated efficiency. For steam engines and turbines, all heat cycles are composed of one or more Rankine cycles. Exact knowledge of the steam cycle and a determination of its cycle efficiency is necessary to obtain engine efficiency from a measured thermal efficiency. A single-expansion steam engine or turbine always operates on a simple Rankine cycle. Multiple-cylinder engines or turbines, in which heat is added or abstracted between cylinders, operate on a number of different Rankine cycles, whose cycle efficiency must be determined for several actual heat quantities and pressure difference. The cycle efficiency of this composite cycle is different from the efficiency of a single Rankine cycle covering the entire range.

The term "Engine Efficiency" may thus be amplified if desired, by writing "Engine Efficiency on the Rankine Cycle," or "Engine Efficiency (Rankine)." It must be understood, however, that this is a distinctly different thing from the Rankine Steam Cycle Efficiency as defined in Paragraph 5. The term "Rankine Efficiency" has been used for both of these things and it must be noted that its use is here abandoned for this reason. The term "Engine Efficiency" may also be amplified by writing "Engine Efficiency of a Turbine-Generator" or "Engine Efficiency of Turbine only." It is not desirable to use such terms as "Turbine-Generator Efficiency" or "Turbine Efficiency." This term may be further amplified when necessary by prefixing the word "Indicated" or "Brake."

Efficiency, Rankine Steam Cycle.—This is the heat cycle efficiency, defined in Par. 3 of the Rankine steam cycle.

$$e_r = \frac{h_1 - h_2}{h_1 - h_3}$$

where h_1 = heat content of steam, at initial condition
h_2 = heat content of steam after adiabatic expansion
h_3 = heat content of the liquid at exhaust pressure

Efficiency, Thermal (Symbol e_t).—Thermal efficiency is defined as the heat equivalent of the work done divided by the heat supplied.

Thermal efficiency of a steam engine or turbine on any steam cycle without reheat or extraction is expressed as follows:

For steam engines:

Indicated thermal efficiency,

$$e_i = \frac{2545}{w_i\,(h - h_1)}$$

For steam engines and turbines:

Brake thermal efficiency,

$$e_b = \frac{2545}{w_b\,(h - h_1)}$$

For engine generators and turbo-generators:

Combined thermal efficiency,

$$e_k = \frac{3413}{w_k\,(h - h_1)}$$

Where w_i = Steam rate referred to indicated horsepower
w_b = Steam rate referred to brake horsepower
w_k = Steam rate referred to net kilowatts
h = Heat content, B.t.u. per lb. at the throttle
h_1 = Heat returnable to boiler, B.t.u. per lb.

The thermal efficiencies of the internal combustion engine are expressed as follows:

Indicated thermal efficiency, $e_i = \frac{2545}{Q_i}$

Brake thermal efficiency, $e_b = \frac{2545}{Q_b}$

Combined thermal efficiency, $e_k = \frac{3413}{Q_k}$

Where Q_i = B.t.u. per net i. hp-hr.
Q_b = B.t.u. per b. hp-hr.
Q_k = B.t.u. per net kw-hr.

The thermal efficiency for complete plants will be expressed in the same way, using i.hp., b.hp. net kw., water hp., air hp., etc., as the reference. For example: The overall thermal efficiency of a coal-fired electric plant is

$$\frac{3413}{\text{Calorific value of coal} \times \text{lb. coal per net kw-hr.}}$$

It is to be noted that in present usage the terms "thermal efficiency" and "cycle" are not limited to the thermodynamic sense only. As used in the Code, they are therefore not to be interpreted in the strictly special manner usual in thermodynamics.

Their use in the general sense is established by custom and is perfectly understandable.

The thermal efficiency of a steam engine, steam turbine or internal combustion engine is an overall efficiency which may be separated into two factors: the cycle efficiency and the engine efficiency.

Thermal efficiency = Cycle efficiency × Engine efficiency.

The engine efficiency may, therefore, be found by dividing the thermal efficiency by the cycle efficiency.

Foot (Symbol Ft.).—Measure of length = 12 in.

Gallon U. S. (Symbol gal.).—=231 cu. in. =.134 cu. ft.

Gravity.—Acceleration due to standard (Symbol g) = 980.665 cm/sec² = 32.1740 ft/sec² which is the actual value of this acceleration at sea level and about 45 deg. latitude. For latitudes between 20 deg. and 70 deg. and altitudes below 5,000 ft., the maximum difference between local and standard gravity is about 1 part in 400, an amount which is ordinarily negligible for engineering purposes.

Heat, Mechanical Equivalent of (Symbol J).—= 778 ft-lb. per B.t.u. For the mechanical equivalent of heat, the following values have been adopted:

J = 778 ft.-lb. = B.t.u.
J = 4.186 Joules per mean gram calorie

Other values which have been used in some of the recent steam tables are: Mollier (1906), 778.28; Marks and Davis (1916), 777.52; Goodenough (1914), 777.64; Callendar (1915), 777.8. The greatest difference of any of these values from 778.00 is about 1 in 1620, an amount which is devoid of physical significance because the uncertainty of the value is at least 1 part in 500. The 15 deg. calorie is known to be about 1 part in 2000, and the mean calorie is known to be nearly the same as the 15 deg. calorie. But the difference between the two is not so accurately known, even its sign being uncertain. In view of this fact it is quite evident that in the value J = 778 ft.-lb. per mean B.t.u., even the 8 is not certain, and that the use of figures beyond the decimal point is a purely illusory refinement. Until standard steam tables are developed, all computations should be made with the value of J upon which the particular steam tables employed are based; otherwise artificial inconsistencies are introduced. The same is true of ammonia and similar tables.

Heat Equivalent of Work (Symbol A).— = 0.001285 B.t.u. per ft.-lb.

Heat Rate.—The heat rate to a steam engine or turbine is the total heat content of the steam entering the engine, plus reheat, less the total heat returnable from engine to boiler per hour per unit of output.

Note.—In case the engine operates on a single Rankine cycle the heat returnable is that heat which is contained in the water at the temperature corresponding to exhaust pressure. For other cycles it is determined by the cycle employed.

The heat rate for a complete steam plant, internal combustion engines and internal combustion plants, is the high calorific value of the fuel multiplied by lbs. of fuel consumed per hour per unit of output.

Horsepower (Symbol hp.).— = 550 ft. lb. per sec. = 33,000 ft. lb. per min. = 1,980,000 ft. lb. per hr. Equivalents: 2,545 B.t.u. per hr.; 745,702 watts; 0.7457 kw.

Horsepower-Hour (Symbol hp. hr.).—Equivalent, 2,545 B.t.u.

Assuming J = 778 ft. lb. per B.t.u.

$$1 \text{ horsepower-hour} = \frac{1{,}980{,}000}{778}$$

= 2544.987 plus B.t.u.

$$1 \text{ kilowatt-hour} = \frac{1{,}980{,}000}{778 \times 0.745702}$$

= 3412.874 plus B.t.u.

Since the value 778 is uncertain by more than one unit, the use of decimal places in the foregoing values is unwarranted and they are abbreviated to 2545 and 3413.

The A.I.E.E. has adopted the value

1 hp. = 746 watts = 550 ft. lb. per sec. (London)
= 550.22 std. ft. lb. per sec.

but inasmuch as the international volt-ampere is now known to be 1.0005 true watts, the above value is not exact, and further, the use of the London ft. lb. in preference to the std. ft. lb. has not been generally adopted. The Bureau of Standards uses 1 U.S. std. hp. = 550 U.S. std. ft. lb. per sec.

Horsepower, Water (Symbol w.hp.).—Water horsepower is to be computed from the equation:

$$\text{Water hp.} = \frac{\text{(lb. of liquid per min.) x (total head in ft. of liquid)}}{33{,}000}$$

Both suction and discharge heads are to be total heads (inclusive of velocity heads) except in cases where the velocity head is less than 0.2 per cent of the total head. In the latter case static pressure, as usually taken by pressure gauges, may be used without correction for velocity head.

If the total head is given as a difference of pressure the value to be used in the foregoing equation is to be found from the formula:

Head in feet=

$$144 \frac{\text{Pressure difference in lb. per sq. in.}}{\text{Actual density of water in lb. per cu. ft.}}$$

Water horsepower for pumps is a measure of the rate at which energy is supplied to the water or other liquid by the pump. In the case of hydraulic turbines it is a measure of the available energy in the water to be employed by the turbine in unit time.

Ice Point and Steam Point.—The ice point is 32 deg. Fahr. and the steam point 212 deg. Fahr., both at saturation pressures corresponding to these two temperatures, respectively.

Kilowatt (Symbol kw.).— = 1000 watts. Equivalents: 1.3410 hp.; 3413 B.t.u. per hr.; 737.56 ft. lb. per sec.

Kilowatt Hour (Symbol kw. hr.).—Equivalents: 1.3410 hp. hr.; 3413 B.t.u.

Mercury.—The density of mercury at 32 deg. Fahr. is 13.5955 grams per cu. cm. (Kaye & Laby, 1918). The mean cubical expansion between 32 deg. Fahr. and 212 deg. Fahr. is 0.0001014 per deg., and from 32 deg. to 110 deg. Fahr. it is 0.0001010. The factor for reducing inches of mercury to lbs. per sq. in. is 0.4912 at 32 deg. Fahr. For values at other temperatures see Weather Bureau Circular F. or Marks and Davis' Steam Tables.

Pound, Force (Symbol lb.).—A force represented by the weight of one pound mass where gravity has the standard value.

Pound, Foot- (Symbol ft.-lb.).—The work done by 1 lb force when its point of application moves one foot in the direction of the force.

Pound, Mass (Symbol lb.).—0.4535924 times the mass of the international prototype kilogram.

Pressure, Back.—The back pressure or exhaust pressure for steam engines or turbines is defined as the pressure obtained at or as near as possible to the exhaust flange. For further details, see A.S.M.E. Codes on Instruments and Apparatus, Steam Engines, Steam Turbines and Condensing Apparatus.

Pressure, Initial Steam.—The initial steam pressure for any steam engine or turbine is defined as the average pressure obtained in the supply pipe directly preceding the throttle valve of the engine or turbine. The same definition will apply to any other apparatus using steam and using a stop valve to start or stop it.

Steam Cycle, Rankine.—The Rankine steam cycle consists of

(a) admission at constant pressure and temperature.
(b) adiabatic expansion to the back pressure.
(c) exhaust at constant pressure and temperature.
(d) return to the boiler of the equivalent amount of feedwater, taken at the temperature and pressure of the exhaust steam; there is to be no heat leakage and no friction, so that all stags of the cycle are ideally perfect.

Steam, Quality of.—The quality of steam or other vapor is specified in two ways: If the vapor is superheated, the quality is described by stating the number of degrees of superheat. If the vapor is wet, the quality is described by stating the dryness factor; for example, if steam contains 2½ per cent of moisture, its dryness is 0.975.

Dry steam, to which most steam conditions involving wet steam were formerly corrected, is that condition at which there is present no moisture and no superheat, and the heat content is that of the saturated vapor. It is a condition which cannot be exactly realized commercially, and as the correction to dry steam has never been applied to superheated steam, it appears advisable to discontinue its use. This does not bar its employment, as a condition together with a definite pressure (and back pressure or vacuum) for correcting guarantee tests to a common state.

Steam Rate.—The steam rate of an engine turbine, or complete steam plant is the pounds of steam per hour under actual conditions, per unit of output; it is to be corrected neither for moisture nor superheat. For further details in application, reference should be made to the Individual Test Codes on Reciprocating Steam Engines, Steam Turbines, Reciprocating Steam Pumps and Complete Steam Plants.

Temperature, Absolute (Symbol T).—The absolute temperature in Fahrenheit degrees is denoted by T, and temperature on the ordinary Fahrenheit scale by t, the relation between the two being

$$T = t + 459.6$$

and the absolute temperature of the ice point being T_o = 491.6. The values are uncertain by about two units in the last place given. For all ordinary engineering purposes, such as reduction of gas volumes, the values 460 and 492 are more than sufficiently accurate.

Theoretical Horse Power Required to Raise Water to Different Heights

From the Novo Handbook

HEAD IN FEET

GALLONS PER MINUTE — Ft.	10	15	20	25	30	35	40	45	50	60	75	80	85	90	100
10	.03	.04	.05	.06	.08	.09	.10	.11	.13	.15	.19	.20	.22	.23	.25
20	.05	.08	.10	.13	.15	.18	.20	.22	.25	.30	.38	.40	.42	.45	.50
30	.08	.11	.15	.19	.23	.26	.30	.34	.38	.45	.57	.60	.63	.68	.75
40	.10	.15	.20	.25	.30	.35	.40	.45	.50	.61	.76	.80	.85	.91	1.01
50	.13	.19	.25	.32	.38	.44	.50	.57	.63	.76	.95	1.00	1.06	1.14	1.26
75	.19	.28	.38	.47	.57	.66	.76	.85	.95	1.14	1.42	1.50	1.77	1.70	1.89
100	.25	.38	.50	.63	.76	.88	1.01	1.14	1.26	1.51	1.89	2.00	2.13	2.27	2.52
125	.32	.47	.63	.79	.97	1.10	1.26	1.42	1.58	1.89	2.37	2.50	2.66	2.84	3.16
150	.38	.57	.76	.95	1.14	1.32	1.52	1.70	1.89	2.27	2.84	3.00	3.19	3.41	3.79
175	.44	.66	.88	1.10	1.32	1.54	1.78	1.99	2.21	2.65	3.31	3.50	3.72	3.98	4.42
200	.50	.76	1.01	1.26	1.52	1.77	2.02	2.27	2.52	3.03	3.79	4.00	4.25	4.54	5.05
250	.63	.95	1.26	1.58	1.90	2.20	2.52	2.84	3.16	3.79	4.73	5.00	5.31	5.68	6.31
300	.76	1.14	1.51	1.90	2.27	2.65	3.03	3.41	3.79	4.54	5.68	6.00	6.37	6.82	7.58
350	.88	1.33	1.77	2.21	2.65	3.09	3.54	3.98	4.42	5.30	6.62	7.00	7.44	7.95	8.84
400	1.01	1.52	2.02	2.52	3.03	3.53	4.04	4.55	5.05	6.06	7.57	8.00	8.50	9.09	10.10
500	1.26	1.90	2.52	3.16	3.78	4.42	5.05	5.69	6.31	7.58	9.47	10.00	10.63	11.36	12.63
550	1.39	2.08	2.78	3.47	4.17	4.86	5.56	6.26	6.94	8.33	10.42	11.00	11.69	12.50	13.89
600	1.52	2.28	3.03	3.79	4.55	5.30	6.06	6.82	7.58	9.09	11.36	12.00	12.75	13.64	15.15
650	1.64	2.47	3.28	4.10	4.93	5.75	6.56	7.39	8.21	9.85	12.31	13.00	13.81	14.77	16.41
700	1.77	2.66	3.54	5.42	5.30	6.19	7.07	7.96	8.84	10.60	13.26	14.00	14.88	15.91	17.68
750	1.89	2.85	3.79	4.74	5.68	6.63	7.58	8.53	9.47	11.36	14.20	15.00	15.94	17.04	18.94
800	2.02	3.04	4.04	5.05	6.06	7.07	8.08	9.10	10.10	12.12	15.15	16.00	17.00	18.18	20.20
850	2.15	3.23	4.29	5.37	6.44	7.51	8.58	9.67	10.73	12.87	16.10	17.00	18.10	19.32	21.46
900	2.27	3.42	4.54	5.68	6.82	7.95	9.09	10.24	11.36	13.63	17.04	18.00	19.13	20.45	22.73
950	2.40	3.60	4.80	6.00	7.20	8.40	9.60	10.80	11.99	14.39	17.99	19.00	20.20	21.59	23.99
1000	2.52	3.79	5.05	6.31	7.58	8.84	10.10	11.36	12.63	15.15	18.94	20.00	21.25	22.73	25.25
2000	5.05	7.57	10.10	12.63	15.15	17.67	20.20	22.72	25.25	30.30	37.87	40.00	42.50	45.45	50.50

Theoretical Horse Power Required to Raise Water to Different Heights

From the Novo Handbook

HEAD IN FEET

GALLONS PER MINUTE — Ft.	150	200	250	300	350	400	450	500	600	700	800	900	1000	1100	1200
10	.37	.50	.62	.75	.87	1.00	1.13	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
20	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
30	1.12	1.50	1.87	2.25	2.62	3.00	3.38	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00
40	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00
50	1.87	2.50	3.12	3.75	4.37	5.00	5.63	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00
75	2.81	3.75	4.69	5.62	6.56	7.50	8.44	9.37	11.25	13.13	15.00	16.88	18.75	20.57	22.50
100	3.75	5.00	6.75	7.50	8.75	10.00	11.25	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00
125	4.69	6.25	7.81	9.37	10.94	12.50	14.06	15.63	18.75	21.88	25.00	28.13	31.25	34.32	37.50
150	5.62	7.50	9.37	11.25	13.12	15.00	16.87	18.75	22.50	26.25	30.00	33.75	37.50	41.25	45.00
175	6.56	8.75	10.94	13.12	15.31	17.50	19.69	21.86	26.25	30.63	35.00	39.37	43.75	48.07	52.50
200	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	30.00	35.00	40.00	45.00	50.00	55.00	60.00
250	9.37	12.50	15.72	18.75	21.87	25.00	28.13	31.50	37.50	43.65	50.00	56.25	63.00	68.75	75.00
300	11.25	15.00	18.75	22.50	26.25	30.00	33.75	37.50	45.00	53.50	60.00	67.50	75.00	82.50	90.00
350	13.12	17.50	21.87	26.25	30.62	35.00	39.38	43.75	52.50	61.25	70.00	78.75	87.50	96.25	
400	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	60.00	70.00	80.00	90.00	100.00		
500	18.75	25.00	31.25	37.50	43.75	50.00	56.25	62.50	75.00	87.50	100.00				
550	20.63	27.50	34.38	41.25	48.13	55.00	61.88	68.75	82.50	96.25					
600	22.50	30.00	37.50	45.00	52.50	60.00	67.50	75.00	90.00						
650	24.38	32.50	40.63	48.75	56.88	65.00	73.13	81.25	97.50						
700	26.25	35.00	43.75	52.50	61.26	70.00	78.75	87.50							
750	28.13	37.50	46.88	56.25	65.63	75.00	84.38	93.75							
800	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00							
850	31.85	42.50	53.13	63.75	74.38	85.00	95.63								
900	33.75	45.00	56.25	67.50	78.75	90.00									
950	35.63	47.50	59.38	71.25	83.13	95.00									
1000	37.50	50.00	62.50	75.00	87.50	100.00									
2000	75.00	100.00													

DAYTON-DOWD COMPANY

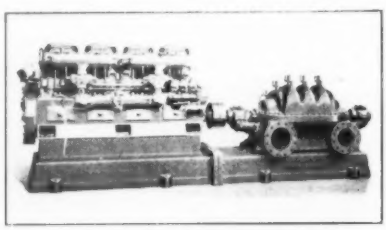
Main Offices and Works: Quincy, Illinois, U. S. A.

Manufacturers of Centrifugal Pumps

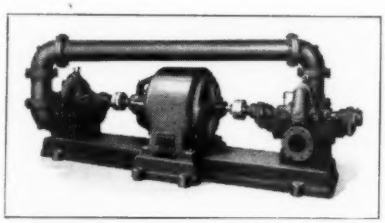
Salt Lake City, 206 South West Temple.
Spokane, Wash., South 118 Lincoln St.
Chicago, 30 North Michigan Blvd.
San Francisco, 7 Front St.
New York City, 369 Lexington Ave.
Washington, D. C., 1816 Park Road, N. Y.
Indianapolis, State Life Bldg.
Milwaukee, 548 Milwaukee St.
Oklahoma City, 301 Local Bldg.
Richmond, Va., Electric Bldg.
Toronto, 610 Federal Bldg.
Edmonton, Can., 10238 104th St.
Cleveland, Ohio, Engineers Bldg.
St. Paul, Minn., 6th and Rosabel Sts.
Omaha, Neb.
Detroit, Mich., 622-4 First St.
Cincinnati, O., Mercantile Library Bldg.
Birmingham, Ala., Moore-Handley Hardware Co.
Baltimore, Md., 120 South Calvert.
Winnipeg, Can., 103 Princess St.
Atlanta, Ga., Hurt Bldg.
Montreal, Can., 1605 Delorimier Ave.
Portland, Ore., 816 Lewis Bldg.
Boston, Mass., 250 Stuart St.
St. Louis, Mo., 2211 Olive St.
Philadelphia, Pa., 1524 Chestnut St.
Vancouver, Can., 609 Credit Foncier Bldg.
Davenport, Iowa, 2108 Grand Ave.
Charlotte, N. C., 101 Kinney Bldg.
Louisville, Ky., 1197 Starks Bldg.
Pittsburgh, Pa., Farmers' Bank Bldg.
Los Angeles, Calif., 722 American Bank Bldg.
Denver, Colo., 618 Exchange Bldg.
New Orleans, La., 1506-7 Masonic Temple.
Houston, Tex., 2d National Bank Bldg.
Memphis, Tenn., 704 Dermon Bldg.
Carthage, N. Y., 616 Alexandria St.
Seattle, Wash., 2726 First Ave., S.
Phoenix, Ariz., Pratt Gilbert Hardware Co.
Duluth, Minn., 316 Glencoe Bldg.
San Benito Texas, P. O. Box 404.
Tulsa, Okla., 211 Commercial Bldg.
Tacoma, Wash., 2123 Pacific Ave.
Butte, Mont., Ben F. Evans.

Products: CENTRIFUGAL PUMPS; SINGLE-STAGE, DOUBLE SUCTION; MULTI-STAGE, AUTOMATICALLY BALANCED TYPE; APPROVED UNDERWRITERS' FIRE PUMPS; OPEN IMPELLER NON-CLOGGING SEWAGE PUMPS, VERTICAL AND HORIZONTAL. Dayton-Dowd Centrifugal pumps embody the most advanced principles of pump engineering in which a fine balance between theory and practice have been established. This, plus the high standards of manufacture, assure the purchaser the utmost satisfaction over a long period of time. **Several Fundamental Points of Pump Design Exemplified in Dayton-Dowd Construction:** First, efficiency of operation. Exact scientific knowledge and the experience of many years are combined in the design of casings and impellers to obtain the highest efficiency possible under various conditions. The water passages are of the correct size and shape to convert most efficiently the velocity into pressure. Second, accessibility. The rotating element of Dayton-Dowd centrifugals may be removed in a few moments by merely lifting the top half casing and bearing caps. The piping is not disturbed. Split glands with swing bolts and plenty of room make packing the boxes an easy matter. Third, interchangeability of parts. Jigs and fixtures are used throughout. All parts are machined to limit gauges and templates. Interchangeability of parts, therefore, is certain. Fourth, strength and long life. Dayton-Dowd pumps are rugged in construction. A generous factor of safety has been allowed which minimizes breakdown and repair bills.

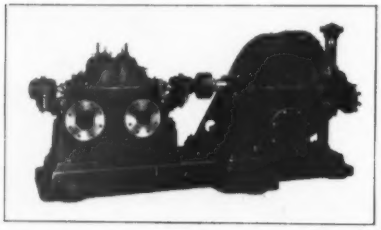
Every Pump Fitted to Individual Needs: The selection of a centrifugal pump involves a careful investigation and consideration of the conditions under which the pump is to operate in order that the pump may be designed with the proper "characteristic curve" to obtain the most economical results. This characteristic or "head volume" curve shows the capacity of the pump at various heads when running at constant speed. Inasmuch as Dayton-Dowd pumps are always designed to fit the particular requirements of each individual order, the most practical relationship between efficiency and head volume is always assured. **Type C S Dayton-Dowd Pumps:** Type C S Pumps are of



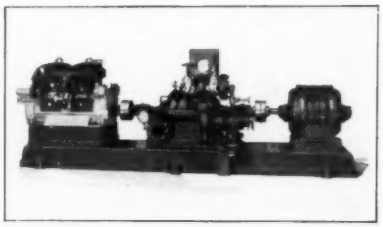
Type CSD Automatically Balanced Multi-Stage Gasoline Engine Driven Pump



Type CS Pumps Connected for Series Operation with Motor Mounted Between Pumps



Type CSD Automatically Balanced Multi-Stage Pump Direct Connected to Steam Turbine



Fire Pump with Dual Drive-Electric Motor and Gasoline Engine for Standby Service

Continued on Next Page

the single stage, double suction types built in sizes from 1½ in. to 48 in. discharge, capacities ranging from 40 gallons per minute to 65,000 gallons per minute. Adapted for any head up to 200 ft. Pumps regularly furnished bronze fitted, but for special service are built of acid resisting bronze or other alloys indicated by the service to be performed. Pumps are of the split-case design; rotor entirely removable without disturbing piping. Impeller design has power-limiting characteristic, protecting motive power from overload in case the head drops off. Ask for Bulletin 267.

Type C S D Multi-Stage Pumps: Are of the automatically balanced type. There are no thrust bearings. Pumps are of split case design; interior of the pump can be inspected by simply removing cover of pump. Built in sizes from 2 in. discharge to 14 in. discharge for capacities from 30 gallons per minute to 7,000 gallons per minute against practically any desired pressure. Adapted for motor, high-speed turbine or other methods of drive. Ask for Bulletin 300.

The C S D F Underwriters' Fire Pumps: Are approved by all Boards of Fire Underwriters. Built in 500, 750, 1,000 and 1,500-gallon-per-minute sizes for motor, steam turbine or gasoline engine drive. Built in accordance with underwriters' specifications. Ask for Bulletin 500.

Bulletins on Dayton-Dowd Centrifugal Pumps:

Type C S and C S L H—General Service Pumps, Bulletin 267.

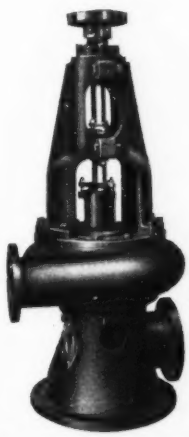
Type C S T Power Limiting Tank Filling and House Pumps, Bulletin 600.

Type S B Belt Driven, Single Suction, General Service Pump, Bulletin 700.

Type C S D Automatically Balanced High Pressure Pumps, Bulletin 300.

Type C S D F Single and Multi-Stage Underwriters' Fire Pump, Bulletin 500.

Type H R Automatic Condensate Return Pumps, Bulletin 900.



Type CV Vertical Non-Clogging Raw Sewage Pump. Has Many Exclusive Features of Design. Impeller and Shaft Entirely Removable Without Disturbing Line Shaft, Pipe Connections or Foundation Alignment

Type S S V Vertical Sump Pumps and Sewage Ejectors, Bulletin 1100.

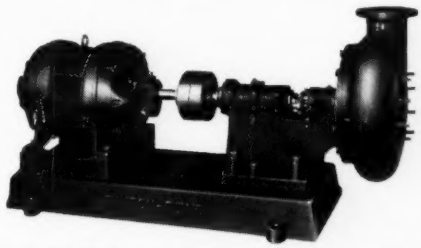
Type T F Turbine Driven Boilers Feed Units, Bulletin 265.
Type N H Motor Driven Brine and Water Pumps, Single Sec., Bulletin 800.

Type C H Non-Clogging Horizontal and Vertical Sewage Pumps, Bulletin 1200.

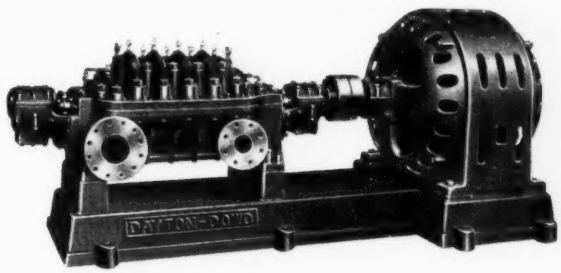
Type S **Paper Stock** Pumps, Bulletin 1300.

Copies of any of these Bulletins will be sent on request.

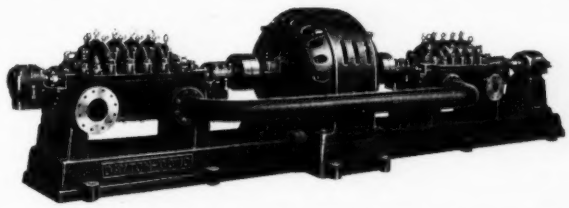
Engineering Service: The experience of our enginering staff is available without obligation in connection with any pumping problems. Special pumps for handling corrosive liquids will be made where indicated. We pour all mixtures of metal, special bronzes, aluminum, lead, cast iron, etc.



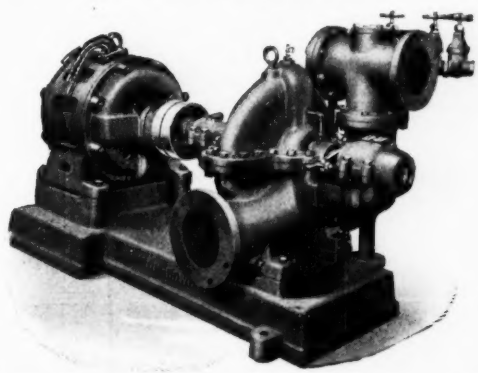
Type CH Horizontal, Non-Clogging Sewage Pump



Type CSDX High Pressure Multi-Stage Automatically Balanced Pump



Type CSDX High Pressure 10-Stage Series Pump. This Unit Designed for 500 GPM, 1,300 Ft. Head



Type CSF Single Stage Motor-Driven Approved Underwriters' Fire Pump. Also Built in Multi-Stage Design

MANISTEE IRON WORKS COMPANY

Manistee, Mich.

Manufacturers of Centrifugal Pumps, Rotary Jet Air Pumps, Rotary Jet Condensers

BRANCH OFFICES

Birmingham, Ala.	Chicago, Ill.	Dallas, Tex.	Milwaukee, Wis.	Philadelphia, Pa.	San Francisco, Calif.
Boston, Mass.	Cincinnati, Ohio.	Denver, Colo.	New Orleans, La.	Pittsburgh, Pa.	St. Louis, Mo.
Cedar Rapids, Iowa.	Cleveland, Ohio.	Detroit, Mich.	New York, N. Y.	Salt Lake City, Utah.	St. Paul, Minn.

Products: ROTURBO CENTRIFUGAL PUMPS, ROTARY JET AIR PUMPS, ROTARY JET CONDENSERS.

Also manufacturers of Vacuum Pumps, Fire Protection Pumps, Vacuum Evaporators.

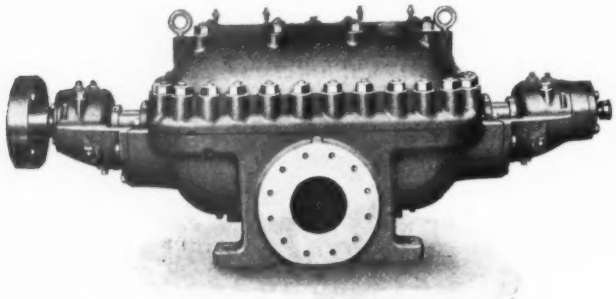
Characteristics of the Manistee Roturbo Pump: The distinguishing feature of the Manistee Roturbo Pump is the construction of the impeller. It differs from the ordinary flat disc runner or impeller.

In the Roturbo impeller the cross section area from the inlet to the outlet is constant. Thus it forms an accumulator for storing water at constant pressures. The cross section area of the common type of impeller gradually diminishes. This results in a gradual acceleration of the velocity of the water. In the Roturbo impeller a large amount of water is subjected to centrifugal force at all times. This generates pressure head directly. The ordinary impeller generates principally velocity energy, leaving it to the diffuser or volute to turn this velocity energy into pressure head. This method is always a very inefficient transformation.

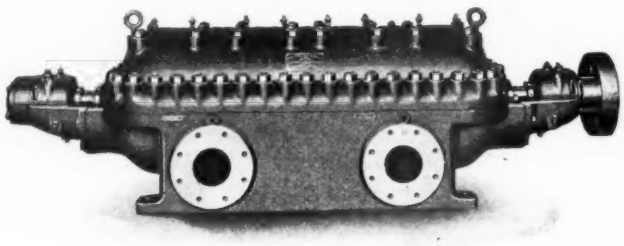
The rim of the Roturbo impeller is arranged with a series of turbine blades curved in an extreme rearward direction relative to the direction of rotation. Due to the water passing through the nozzles formed by these turbine blades, 25 per cent of the pressure energy generated by the impeller is transformed into velocity energy. This velocity energy reacts upon the turbine blades and assists in driving the impeller. In other words, it decreases the power required to drive the impeller. As more water passes through the impeller, due either to an increase in pump speed or a decrease in head, this reaction effect becomes greater. It is possible consequently to operate the pump under any condition of head or volume without overloading the driver. The salient features brought about by this type of impeller are as follows:

1. High Efficiency.
2. Lasting Efficiency.
3. Flat power curve with varying discharge.
4. A flat efficiency curve with varying discharge.

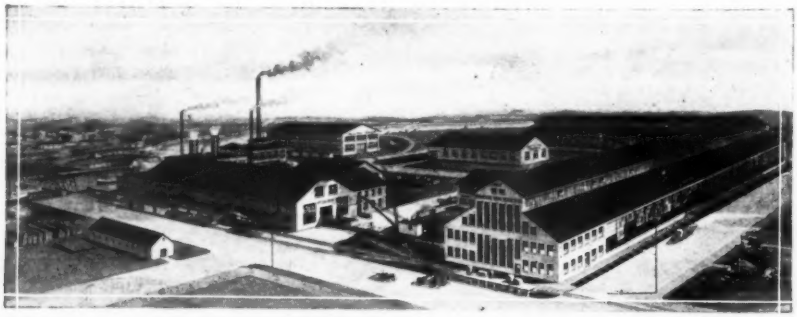
The comparatively high efficiencies obtained by the Manistee Roturbo Pump are due largely to the pressure chamber impeller. On account of the impeller generating the pressure head directly and discharging the liquor with only 25 per cent of its total energy in velocity, the losses in effi-



Four Stage Horizontal Split Roturbo Pump, Type H4



Eight Stage Horizontal Split Roturbo Pump, Type H8



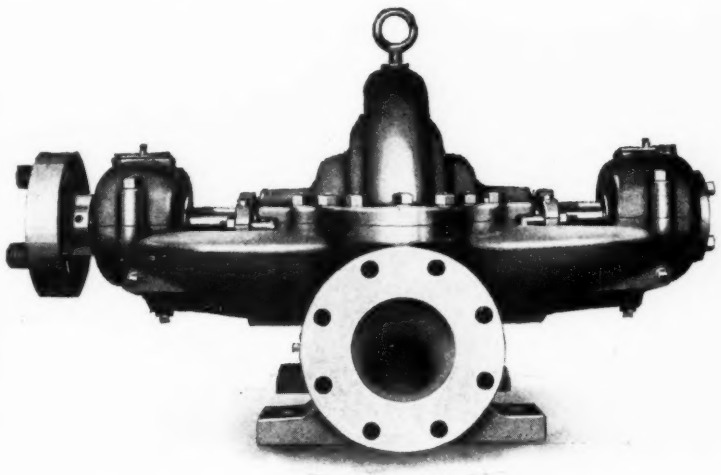
Factory and Main Offices

ciency are very small. As the amount of velocity energy is comparatively small, a very simple form of diffuser can be used. The clearances between the rim of the impeller and the diffuser blades are very large, eliminating the necessity for removable diffuser blade tips.

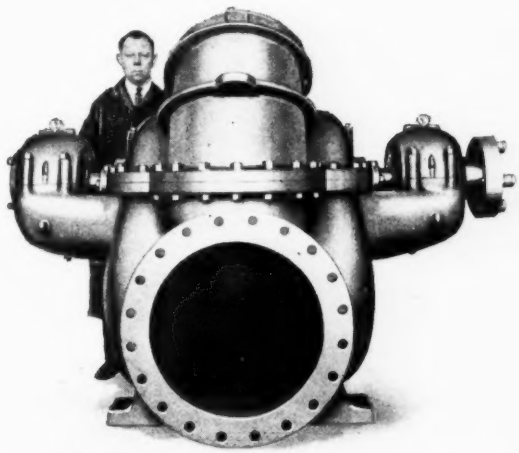
The efficiencies are made more permanent and lasting on account of the extreme low velocity of water through the pump. This causes only a minimum wear on the impellers and diffusers. In the ordinary Centifugal Pump there are considerable losses in efficiency on account of the action of high velocity water on the different metals. It will also be found that there are more stages in a Manistee Roturbo Pump for creating a specified pressure than in the ordinary type of Centrifugal Pump.

The inherent non-overloading type of Roturbo impeller gives to the pump a great deal more useful work energy at the lower heads than the ordinary type. This useful work at lower heads bolsters up and maintains the high efficiency of Roturbo pumps over a wide range. This naturally increases the efficient useful work the pump can perform. In short, at lower heads than specified the Roturbo impeller pump will give more water with the same or less power.

The casing is split horizontally and both branches are cast integral with the lower half casing. Great care is taken in the pouring of metal in the casing in order to secure the exact shape and perfect smoothness necessary for correct water flow.



Volute Type Single Stage Roturbo Centrifugal Pump



Volute Type Single Stage Roturbo Centrifugal Pump

The object of this is to reduce to a minimum the difference in pressures between stages, consequently less losses in efficiency due to leakage.

The characteristic curve of the Roturbo impeller approaches most nearly the ideal head and volume curve for a Centrifugal Pump impeller. This ideal curve is one on which there are no unstable points, so that when operating at a constant speed, there is a different capacity for each condition of head. The highest pressure is obtained when the discharge of the pump is completely shut off. There is a gradual increase in volume as the head is reduced. The curve also shows that at zero head the capacity is 190 per cent of normal.

The brake horsepower curve is of the non-overloading type. At no condition of head or capacity does the power exceed by more than a few per cent the power required to drive the pump at normal capacity. This curve is obtained on account of the extreme rearward direction of discharge of the water, which has a turbine effect on the impeller.

The non-overloading type of power curve can be obtained with the ordinary pump impeller by restricting the area of the inlet water passages. This chokes or limits the amount of water that can pass through the impeller. The result is a head and volume curve which drops off abruptly. Thus when the head is reduced below normal or even as low as zero head, the increase in capacity is very small. This has its effect on the brake horsepower curve which drops off abruptly at the reduced heads.

The Manistee Roturbo Single Stage Pumps are famous for their ruggedness, simplicity and high economy.

Specification for Manistee RoTURBo Horizontally Split Multi-Stage Type Pumps

Casing: The casing will be of the horizontally split type with the suction and discharge openings cast integral with the lower half. The material used will be close grained cast iron or bronze as per detail specifications, accurately machined and free from flaws or other defects.

Hydrostatic Test: Each casing will be given a hydrostatic test of double the pressure of that to which it will be subjected in actual service.

Bearings: The bearings will be of the ring lubricated babbitt type, having very large oil reservoirs.

Diffusers: The stationary diverging channels will be cast iron or bronze, properly machined and made removable and renewable, and fitted with removable and renewable diffuser and eye rings.

Stuffing Boxes: The stuffing boxes will be of ample depth. Metallic packing will be used throughout.

Impeller: Will be of the RoTURBo patent pressure chamber type of cast iron or bronze as per detailed specifications and will be fitted with removable bronze eye rings and bridge rings.

Hydraulic Balance: Impeller will be hydraulically balanced with reference to end and lateral thrust at all speeds.

Shaft: The shaft will be of ample size to transmit the maximum power required without stress or vibration. It will be accurately machined and polished, and provided with bronze sleeves.

Coupling: When pump is arranged for direct connection to prime movers, a flexible coupling will be provided to compensate for slight variation in alignment.

Pulley: When pump is for belt drive, suitable cast iron pulley and outboard bearing will be provided instead of flexible coupling.

Baseplate: The baseplate will be of cast iron, heavy section, suitably ribbed to prevent distortion and extended to receive prime mover or pulley.

Painting: After completion, the interior of the pump will be given one coat of anti-rust paint and the exterior will be suitably covered with dull finish machinery paint. All bright parts will be carefully protected against rusting in transit.

General: The pumps will be well finished throughout and all material will be as per detailed specifications. The workmanship will be first class in all respects.

PEERLESS PUMP COMPANY

Manufacturers of Moturbo Deep-Well Turbine Pumps

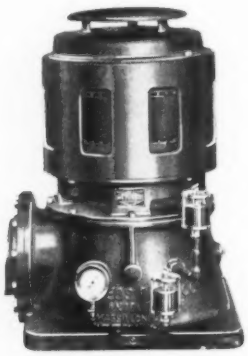
Western Factory, Los Angeles, California, Eastern Factory, Massillon, Ohio

DISTRICT REPRESENTATIVES

Portland, Ore., 355 Everett St.
Yuma, Ariz., 1120 Fifth Ave.
San Francisco, Calif., Room 314, 7 Front St.
Sacramento, Calif., 1327 O St.
San Jose, Calif., 635 South First St.
Fresno, Calif., 1255 Broadway
Bakersfield, Calif., 1514 20th St.
Tulare, Calif., South K and Owens Sts.
Lancaster, Calif.
Amarillo, Tex., 717 Amarillo Bldg.
South America, PO. Box 286, Hanover Square, New York City.
New York, Room 513, 51 E. 42nd St.
Chicago, Room 532, 9 So. Clinton St.
Pittsburgh, Pa., 1601 Arrott Bldg.
Baltimore, Md., 321 Equitable Bldg.
Detroit, Mich., 414-420 Curtis Bldg. 2842 W. Grand Blvd.
Indianapolis, Ind., 945 N. Denny St.
St. Louis, Mo., 923 Chemical Bldg.
Kansas City, Mo., 411 Mutual Bldg.
St. Paul, Minn., 1603 University Ave.
Duluth, Minn., Providence Bldg.
Des Moines, Ia., 207 W. Court Ave.

Products: MOTURBO DEEP WELL TURBINE PUMPS.

Moturbo, with Power Unit Integral: Moturbo is a deep well turbine pump designed for the purpose of lifting water for municipal, industrial and private use. It is a compact, self contained unit with electric auto-controlled driving mechanism integral with the pump head. A simple push button switch controls its operation. It is built in five standard sizes—the power unit ranging from 7½ to 150 H. P.; larger sizes are built upon specifications.



Moturbo

Contrary to the common practice of pump manufacturers of building their product to conform to the driving mechanism, Moturbo is a complete manufactured product. The driving mechanism manufacturers have never built a unit specially for turbine pump operation. This is due to the fact that driving mechanisms are required to cover a wide range of duty. To overcome the compromise in design made necessary by this fact, a special power unit had to be built.

Every part used in Moturbo construction was designed to conform to turbine pump requirements. The complete unit from the intake screen to the cover cap is guaranteed by the Peerless Pump Company.

Cold Oiled—Water Cooled Bearings: All Moturbo bearings are lubricated by cold oil. The oil lubricating the ball thrust and the top ball bearing is kept at an evenly cool temperature by discharging water which surrounds the oil bowl.

The oil is circulated in a steady flow by a spiral rotary pump. It is carried up and through the top bearing and returned downward, through holes provided for this purpose in the casting on the outside of the bearing race, to the oil bowl. The bottom bearing of the pump bowls and shaft line bearings are lubricated from sight feed oil cups by gravity. Cold oil is delivered to these bearings in pre-determined quantities. Moturbo fulfills every requirement of an efficient electrically driven unit and renders obsolete many kinds and designs of deep well turbine pumps.

H. S. D. C.

Peerless Deep Well Turbine Pumps: There are conditions however, that require gas or steam-driven prime movers

B. M. P.

and there are times when the purchaser may desire to use some standard make of motor other than the Auto Control

driving mechanism that forms an integral part of Moturbo construction. To meet such demands, the Peerless Pump Company is manufacturing belt-driven units and heads designed for direct connection to any other standard make of vertical motor. In its sphere this equipment represents as high a standard of development as does Moturbo. Its construction embodies many of the features that helped gain for Moturbo its position in the industrial world. All adjustments of pump runners and shafting can be made without removing the motor or pulley from the pump head. This is a feature rarely found in ordinary units built to accommodate standard vertical motors. In the case of belted-drive units, pulley can be changed without changing adjustment of runners. Peerless units, including Moturbo, combine a range of pumping equipment from which can be obtained the proper unit to fulfill efficiently and economically any pumping requirement.

Underground Discharge: It is convenient under some circumstances to be able to convey the water away from the well-site under the surface of the ground by means of an underground piping system. The two Peerless units that have been designed to this purpose are types B. M. P. and M. U. D. C., one of which is above.

Type M. S. D. C. Full Floating Direct-Connected Head: For direct connection to vertical motors up to, and including, 125 H. P. 6 Pole and 150 H. P. 4 Pole. Ball or plate bearings can be used depending upon the depth of the pump. All bearings are incased in an oil bath which is water cooled.

Pump runners and shaft can be adjusted without disconnecting motor.

Type H. S. B. Full Floating Belted Head: Designed for application up to, and including, 250 H. P. Two extra Heavy Radial Ball Bearings are used to receive belt pull. The thrust load is carried on an extra heavy Segment Plate Bearing operating in water cooled oil.

Special installations are available for up to 400 H. P. Belt Drive using four specially mounted Timken Bearings to take belt pull, now in operation on 600 ft. lifts.

Capacities Obtainable

	G.P.M.
For wells 6 in. I. D. or larger	up to 150
For wells 7 in. I. D. or larger	up to 450
For wells 8 in. I. D. or larger	up to 600
For wells 10 in. I. D. or larger	up to 1100
For wells 12 in. I. D. or larger	up to 1500
For wells 14 in. I. D. or larger	up to 2200
For wells 16 in. I. D. or larger	up to 3500
For wells 18 in. I. D. or larger	up to 5000
For wells 20 in. I. D. or larger	up to 6000

Pulley can be changed without changing adjustment of runners. The heavy sub-base insures a rigid foundation.

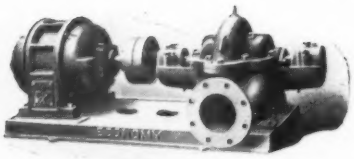
Type H. S. D. C. Full Floating Direct Connected: For direct connection to any make of standard motor up to 400

H. P. The thrust load is carried on an extra heavy Segment Plate Bearing operating in water-cooled oil.

Pump runners can be adjusted without disconnecting motor.

ECONOMY PUMPING MACHINERY CO.

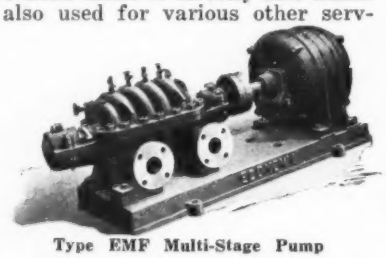
General Office, 3431 West 48th Place, Chicago, Ill.



Double Suction Pump

Economy Pumps

Horizontal Centrifugal Pumps are generally used for water supply, either with overhead tanks or directly into mains as boosters. They are also used for various other services, such as boiler feeding, filter circulation and swimming pool circulation. They are truly general purpose pumps.



Type EMF Multi-Stage Pump

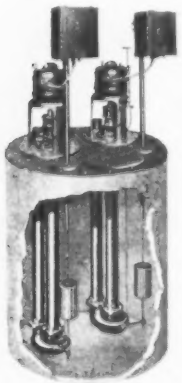
The double suction single stage pumps embody up-to-date hydraulic developments with exceedingly high efficiencies. Their mechanical design is unusually rugged, so that they are fitted for continuous service. Specifications are given in bulletin No. 408.

The high pressure multistage horizontal split case pumps have one piece bronze diaphragm which eliminates leakage between stages. A volute or spiral in every stage results in high pump efficiency without the use of diffusion vanes. The thrust is eliminated with a hydraulic balancing device. See bulletin No. 406 for specifications.

The following table gives only a partial list. Write General Office for detailed information.

Selection Table

Unit No.	Capacity Gallons Per Minute	Total Head in Feet Water	Size Discharge and Type of Pump	Motor Horse Power	Number of Stages	Approximate Floor Space Inches
SC300	150	30	2½"-SM	3	1	20 x 46
SC301	150	60	2½"-SM	5	1	20 x 52
SC302	150	150	2½"-M	10	1	24 x 60
SC303	150	220	2½"-EMF	15	4	24 x 62
SC304	150	300	2½"-EMF	20	6	24 x 70
SC308	150	750	3" -EMF	60	8	34 x 98
SC400	250	30	3" -MF	3	1	22 x 48
SC403	250	80	3" -MF	7½	1	22 x 52
SC408	250	125	2½"-M	15	1	24 x 60
SC409	250	180	3" -H	20	1	30 x 64
SC411	250	375	3" -EMF	40	5	34 x 90
SC412	250	600	3" -EMF	60	7	34 x 98
SC500	500	40	4" -MG	7½	1	26 x 64
SC501	500	80	4" -MG	15	1	26 x 64
SC502	500	150	3" -ME	30	1	34 x 72
SC503	500	200	3" -ME	40	1	34 x 72
SC550	750	40	5" -MH	10	1	26 x 64
SC552	750	110	5" -MH	30	1	26 x 68
SC555	750	200	5" -M	75	1	34 x 84
SC580	1200	30	6" -MJ	15	1	34 x 70
SC581	1200	80	6" -MJ	30	1	34 x 75
SC585	1200	200	5" -M	100	1	34 x 98
SC600	3000	80	8" -M	100	1	42 x 106
SC601	3000	140	8" -M	150	1	48 x 112
SC602	3000	200	8" -M	250	1	56 x 124

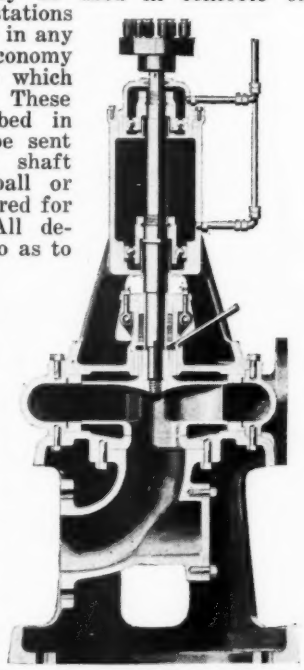


Submerged Type Non-Clogging Pump

Improved Non - Clogging Centrifugal Pumps are made in three designs, all having the same efficient non-clogging impellers but differing in mechanical design. These pumps will handle rags, sticks, etc., which are encountered in unscreened domestic and industrial sewage. The applications of the various types are as follows:

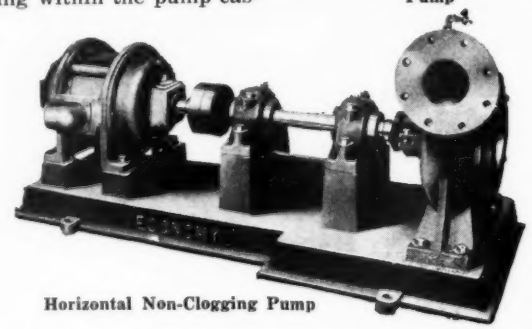
1. Self contained vertical or drop leg type, frequently installed in the smaller isolated plants where the pumps are dropped into the sump and operated submerged without any suction piping, also widely used for draining comfort stations, subways, etc. The patented mechanical design of these pumps adds additional years to their life.

2. The open shaft vertical pumps, generally used in dry pump chamber installations such as are provided in municipal sewage pumping plants, etc. These pumps may be used in concrete or brick pumping stations built in the field or in any of the various Economy steel tank stations which are shipped ready for erection. These pumping stations are described in bulletin No. 411 which will be sent on request. Economy open shaft pumps are built in either ball or sleeve bearing designs as required for the individual application. All designs are pressure lubricated so as to insure continuous service.



Open Shaft Vertical Non-Clogging Pump

3. The horizontal non-clog pumps are used for handling sewage, foodstuffs, paper stock and any other stringy or pulpy material. They are used in sewage disposal plants, garbage reduction plants, or in sewage pumping plants where the pump suction line is above the pump floor level. These pumps may be direct motor driven, belt or chain driven from any suitable power source. They are of unusually rugged design with roller outboard bearings that carry the entire weight of the rotor, there being only a shock bearing within the pump casing.



Horizontal Non-Clogging Pump

The following table gives only a partial list. Write General Office for detailed information.

Selection Table

Capacity G. P. M.		Total Head in Feet					
		15	20	25	30	40	50
150	Size H. P. R. P. M.	3-SSV 1½ 850	4-SSV 2 850	4-SSV 2 850	4-SSV 3 850	4-SSV 5 1150	4-SSV 5 1150
300	Size H. P. R. P. M.	4-SSV 2 850	4-SSV 3 850	4-SSV 5 850	4-SSV 5 850	4-SSV 7½ 1150	4-SSV 10 1150
500	Size H. P. R. P. M.	4-SSV 5 850	6-SSV 5 850	6-SSV 7½ 850	6-SSV 7½ 850	6-SSV 15 1150	6-SSV 15 1150
750	Size H. P. R. P. M.	6-SSV 7½ 850	6-SSV 7½ 850	6-SSV 10 850	6-SSV 10 850	6-SSV 15 1150	6-SSV 20 1150
1000	Size H. P. R. P. M.	6-SSV 7½ 850	6-SSV 10 850	8-SSV 15 850	8-SSV 15 850	8-SSV 20 850	8-SSV 25 850
1500	Size H. P. R. P. M.	8-SSV 10 670	8-SSV 15 670	8-SSV 15 670	8-SSV 20 850	8-SSV 25 850	10-SSV 40 850
2000	Size H. P. R. P. M.	8-SSV 15 670	8-SSV 20 670	10-SSV 25 670	8-SSV 25 850	8-SSV 30 850	10-SSV 50 850
3000	Size H. P. R. P. M.	10-SSV 25 670	10-SSV 30 670	10-SSV 40 850	10-SSV 40 850	10-SSV 50 850	10-SSV 60 850

FULTON IRON WORKS COMPANY

St. Louis, U. S. A.

Plants and Offices at St. Louis, Mo., and Springfield, Ohio

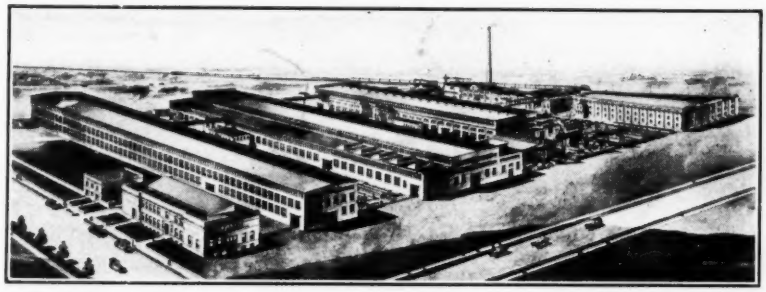
Successful Engine Builders for Over 75 Years

Manufacturers of DIESEL and Internal Combustion Engines
Gray Iron Castings—1 to 100,000 Lbs.—Rough or Machined

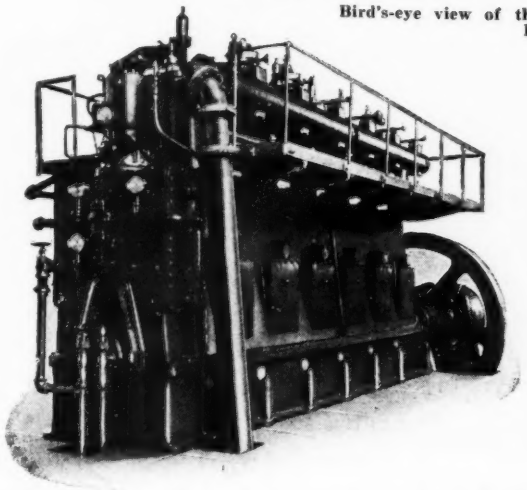
BRANCHES AND AGENTS

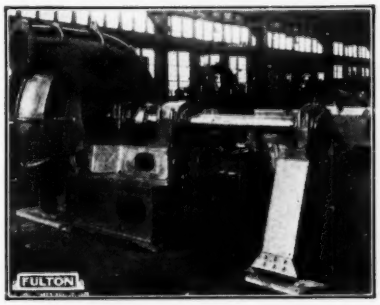
New York	Springfield, Ohio	Salt Lake City	Dallas	Houston	Wichita, Kansas	Boston
Chicago	New Orleans	El Paso	Tulsa	Mobile	Havana	Pittsburgh

We have completely equipped plant with foundries and machine shops employing 2,000 skilled mechanics, experienced engineers, and designers. Complete organization for financing, designing, manufacturing, and selling. Contract work solicited either to build machinery to your specifications or to develop and improve your rough ideas.



Bird's-eye view of the large, modern St. Louis plant of the Fulton Iron Wks. Co.



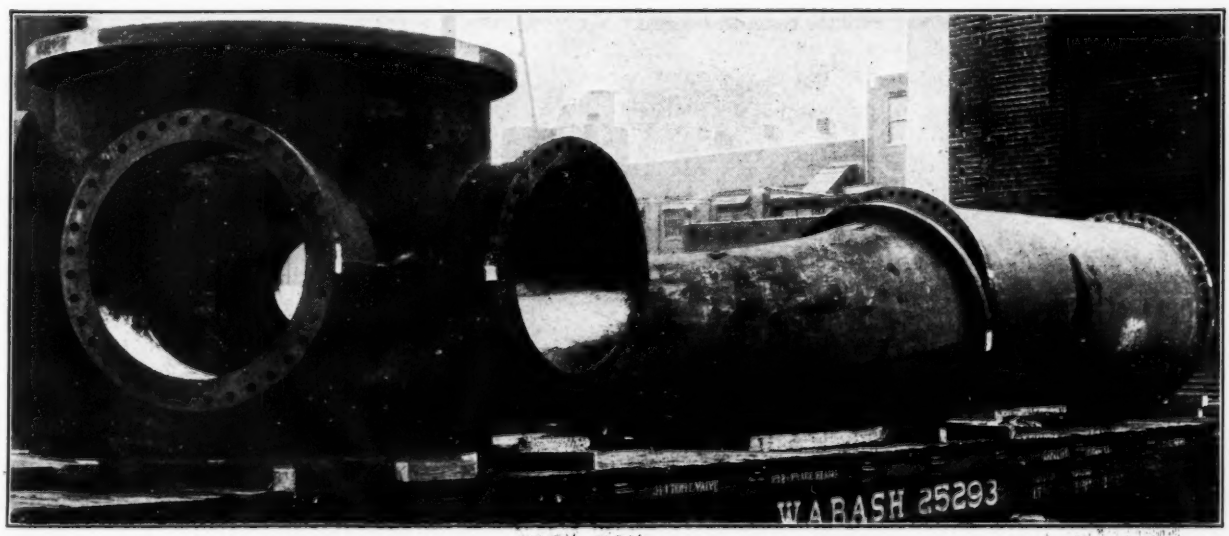


Dredge Pump for Great Lake Service

Fulton-Diesel Type BGS Engine: The Type BG Fulton-Diesel is built in 3, 4, 5, 6 and 8 cylinders with ratings of from 375 to 1,000 B. H. P., operating at 225 R. P. M. It is of the air-injection type and is ideal for heavy, continuous duty. This is one of the many Fulton-Diesels that have been giving dependable, economical power service to many towns and cities. Write for complete literature.

Heavy Castings and Special Machinery: Heavy castings of any type manufactured to specifications, either of gray iron or semi-steel, 1 to 100,000 lbs., rough or machined. Our large, modern foundry and machine shops are specially equipped to render prompt and complete service on Manhole Frames and Covers, Fire Hydrants, Lamp Standards, Sluice Gates, etc. Let us quote you on your needs.

Cast Iron Pipe and Fittings—Made to Any Specifications



MABBS HYDRAULIC PACKING COMPANY

Incorporated 1892

431 S. Dearborn St., Chicago, Illinois

Manufacturers of Mabbs Rawhide Packing

Sold through supply houses throughout the country

MABBS RAWHIDE PACKING NEVER BECOMES HARD OR GLAZED.

It will never cut or score the metal surfaces.

It is practically antifrictional.

When it is wet, it is as slippery as an eel.

It results in a great saving in power.

It works equally as well on either centrifugal or reciprocating pumps.

Trade Mark

Reg. U. S. Pat. Off.

Mabbs Rawhide Packing is a great success for hydraulic presses of all descriptions. Presses working under a pressure of 10,000 lbs. to the square inch have been successfully packed with Mabbs ¼" Solid Rawhide Packing.

Mabbs Rawhide Packing is very desirable for packing brine pumps handling calcium brine.

The Mabbs Rawhide Packing when saturated is too soft to hold the particles of grit upon its surface, but they work back into the body of the Packing. For this reason it can be used to handle very dirty water **without injury** to the shafts and plungers or rods, as is evidenced by the fact that the United States Government has been using this Packing for nearly twenty years on their hydraulic dredges.

When the Mabbs Rawhide Packing is operating on clean liquids it is never necessary to remove the old Packing from the stuffing box; all that is required is to add another ring of Packing occasionally to keep the stuffing box well filled and compensate for wear.

Cases may be cited where brass rods have outworn other parts of the pump when these rods were continuously packed with Mabbs Rawhide Packing.

The Mabbs Rawhide Packing has been installed on brass rods where the stuffing boxes have not been entirely cleaned out in fourteen (14) years, without a mark on the brass rods.

When handling very dirty water, it is a good plan to throw the Packing away occasionally before it becomes completely filled with grit.

After nearly forty years of service in WATERWORKS, it has proven its superiority over any other packing for this purpose.

There is no packing made equal to the Mabbs Rawhide Packing for packing the brass stems of all kinds of water valves and hydraulicly operated valves. If valve stems are packed with this Rawhide Packing continuously, they will operate much freer, and the brass stems will last a life time.

Mabbs Rawhide Packing is particularly desirable for the marine business in such positions as stern tubes, bilge pumps, fire pumps, circulating pumps, sanitary pumps, and brine pumps.

One of the greatest fields where the Mabbs Rawhide Packing has been a pronounced success is the cotton gins in the South where it is almost universally used. This packing is particularly desirable for mining purposes where there is considerable grit and dirt in the water, and also where there may be some acids in the water.

This Packing has proved a great success in the Oil Fields, both on oil pumps and wells.

The Mabbs Rawhide Packing is made in any size from $\frac{1}{16}$" to 3" running by sixteenths of an inch to ¾", and by eighths of an inch on larger sizes.

Any size of this Packing is put up in standard tin pails of 5-10-25 and 50-lbs., and in kegs and barrels of 100 and 200-lbs. The price of the Mabbs Rawhide Packing is $3.00 per lb.

Rawhide Packing is NOT to be used for either steam or hot liquids.

Mabbs Rawhide Packing weighs only two-thirds as much as flax and when ITS LONG LIFE and ANTI-FRICTIONAL QUALITIES are taken into consideration, you will find it the cheapest packing you can procure.

What users say of Mabbs Rawhide Packing

City of Evanston Filtration Plant,
Evanston, Illinois
J. W. Gaitenby, Supt.,

Since the installation of this plant, we have packed our hydraulically operated valves with flax packing and found it necessary to boost the standpipe pressure from 40 lbs. to 80 lbs. by means of a motor driven booster in order to operate these valves successfully. Since installing your Rawhide Packing, we have been able to discontinue the use of this motor driven booster.

Mason City, Iowa
John C. Stier, Chief Engineer of Water Works

I enclose you in separate package today a sample of your packing which has been in constant use for six years.
The rods are in excellent shape and do not show any wear whatever. This pump has been running 365 days in the year.

Bates Expanded Steel Truss Co.
208 S. LaSalle Street,
Chicago, Illinois
A. J. Bates, Secretary

Relative to the square braided rawhide hydraulic packing of your make that we have in service two 26" cylinders with the pistons packed with your packing. They have been in operation now five years under a water pressure of 500 lbs. per square inch.

We make a specialty of Rawhide Meter Washers which are superior to cork

Recent Developments in Water Purification

In a paper presented Sept. 19, 1928, before the New England Water Works Association Wellington Donaldson of Fuller & McClintock, consulting engineers, New York, gave the following outline of recent changes in established practice in the field of water purification.

Speaking generally, the most notable recent advances have been concerned with processes or modifications of processes rather than with new types of structures. Of the structural changes noted in a survey of the more recent purification plants, the most important are concerned with mechanically-cleaned settling basins, mixing facilities and aeration.

Mechanical Clarifiers.—Originally developed as a metallurgical process, the mechanical clarifier has been finding increased favor in water-works practice. Its first point of entry into water-works practice was in connection with softening plants where the voluminous precipitate produced by lime and soda reactions indicated advantages through continuous removal of sludge, in contrast with the usual practice of intermittently emptying and flushing the settling units. The mechanical clarifier, at first circular in plan with crescentic inlet and outlet troughs, has developed into a square plan having more efficient settling characteristics. The early installations were separate, independent structures. The tendency now is to incorporate the clarifier in one end of a rectangular settling basin, the two structures being integral and with a continuous water surface.

The first mechanical clarifier installation of record in connection with municipal water works was at Benton Harbor, Mich.; put in service in 1923. At the present time the mechanical clarifier has been incorporated in the design of some 14 water-softening plants, chief among which are Newark, Ohio; Piqua, Ohio; Springfield, Ill.; Miami, Fla.; and South Pittsburgh, Pa. The efficiency and economy of these devices, in comparison with the older style settling basins, are not yet fully established, but their popularity would indicate that mechanically-cleaned basins of some type are likely to find a permanent place in connection with water softening.

The utility of the mechanical clarifier for removal of the sludge from softening reactions has more recently been extended into other water-purification fields. At Lancaster, Pa., and Decatur, Ill., clarifiers are used to serve in place of ordinary coagulating basins. The latest adaptation is a preliminary sedimentation device for the very turbid waters of the Middle West. The Missouri River, for instance, has an established peak of 15,000 p.p.m., or 62 tons of dry suspended solids per million gal., while values of 5,000 to 8,000 p.p. m. are not uncommon occurrences during the spring and summer months. The customary practice on the Missouri and other muddy western rivers has been to provide extensive preliminary sedimentation in simple rectangular basins. The large amount of sediment deposited in these basins has necessitated putting them out of service frequently for cleaning purposes, with considerable inconvenience to operation and cost for labor and flushing water. These facts have led to the idea of continuous removal of the deposited sediment in a more satisfactory manner than can be obtained by well-sloped or underdrained bottoms. The result has been an incorporation of mechanical clarifiers in at least two of the important Mid-west plants. The Kansas City, Mo., plant, which went into operation in June of this year, has four 200-ft. diameter, circular clarifiers as preliminary sedimentation units. The new Missouri River plant of the St. Louis water works, now under construction, includes five 150-ft., square clarifiers for preliminary sedimentation ahead of the softening processes. Operating results are not yet available at Kansas City under normal conditions to give a comparison with plain rectangular basins as to efficiency of removing suspended solids and operating costs. Until these points are settled, it is fair to regard the matter as in an experimental state, in so far as these two installations may have a bearing on influencing practice in handling excessively turbid waters. They at least constitute a notable modification over the customary plant layout.

Mixing Facilities.—Another feature of filter plant layouts that has been undergoing extensive modification within recent years, is the mixing arrangement for facilitating the chemical reactions connected with softening or coagulation. The lack of flexibility of the older, baffled type of mixing chamber for varied conditions of flow are well recognized and have led in recent years to experimentation with other types of mixing devices, though as yet no standard design has been evolved. The Topeka softening plant has a loosely-baffled chamber with mechanical stirrers. Many of the recent softening plants employ single circular mixing chambers with mechanical stirrers. The Sacramento, San Leandro and Beverly Hills plants employ multiple circular mixers with paddle stirrers, operated in tandem. Knoxville, Tenn., is another recent example. The plants at Providence, R. I., Watertown, N. Y., Albany, N. Y., and Danville, Va., have circular mixing tanks without mechanical stirring devices, the tangential bottom inlets and tangential top outlets being relied upon to produce stirring velocities. The Kansas City and St. Louis works have somewhat similar mixing devices, with the difference that the tangential inlet is at the top while the outlet is at the center of the cone-shaped bottom. The flow is thus downward in a vortex.

Still another notable type is the "hydraulic jump" installed in the new 165-m.g.d. Fairmount filter plant at Cleveland. The same feature is incorporated in plants at Bay City, Mich., Port Arthur, Tex., Hannibal, Mo., Lake Charles, La., and Hamlet, N. C. Most of these newer types of mixing devices appear to be working satisfactorily, with advantages over the older types.

Aeration.—Prior to the general adoption of filtration, aeration was regarded as an effective weapon for combating odors and tastes in stored waters. Later the marked benefits derived from filtration somewhat obscured the advantages of aeration, and many representative filter plants, built a few years ago, were provided with meager or no facilities for aeration. More recently, however, there has been a recrudescence of the aeration idea as water consumers have become more critical of the physical qualities of the supply. In several instances aeration of both raw and filtered water is practiced.

Aeration is now employed for other than the original purpose of overcoming tastes and odors due to plankton growths or the effects of stagnation in stored water. Certain classes of trade waste responsible for taste and odor respond favorably to aeration, though others do not. At West Palm Beach and a few other places, addition of the alum dose prior to passage of the raw water through spray nozzles has been found distinctly helpful in promoting coagulation of a soft colored water. At both Richmond, Va., and Rahway, N. J., it has been found that spray-nozzle aeration is quite effective after substantial pre-chlorination doses in reducing residual chlorine to within non-troublesome limits. Another use for aeration that has come to the front, is its ability to lower the carbon dioxide content, thereby decreasing aggressiveness of the water. This has led to the use of the so-called effluent aerators as exemplified by the plants at Albany, Providence, West Palm Beach and Poughkeepsie.

That the aeration feature, aside from its utility, can be made to serve an ornamental purpose is shown very well by the Kensico and Ashokan installations of the New York water supply, and those at Providence, West Palm Beach and the San Leandro plant of Oakland.

In general, where the need of aeration is plainly indicated, the tendency has been towards the use of fixed spray nozzles in preference to other devices that are not so completely effective. Mention deserves to be made, however, of the floating nozzles in the Sacramento and Beverly Hills installations. In the latter, the released hydrogen sulfide gas is captured and discharged through a tall stack to avoid complaints in a high-class residence district.

Filters.—No important changes in filter design have come to the front recently. There still exists considerable diversity of opinion as to the merits of various styles of underdrain systems; none of them are perfect and most of them are satisfactory. Of the filter appurtenances such as gages, controllers, etc., new designs have appeared within the last year or so, but nothing particularly novel has developed, excepting the substitution of electrical instruments at Wausau, Wis., for the usual filter flow-gage . It seems to be merely a question of healthly competition among the manufacturers.

It is worth noting here the revival of the old Hyatt idea of washing a filter bed by sections instead of as a whole. It will be remembered that some of the early New York

Continental filters employed the "quadrant" wash for a single undivided bed, but the idea fell into disuse. It has been revived in a modified form in some of the recent plants for washing beds made up of separate bays; for instance, at Poughkeepsie and West Palm Beach where the four bed sections are washed independently, and at the San Leandro, Calif., plant where the filter is washed by halves. The purpose obviously is to reduce the size of wash piping required and the demand rate of wash water.

Coagulants.—Much experimentation is continually being carried on in various parts of the country to discover coagulants better suited than is ordinary filter alum to certain types of water and to decrease the cost of the preparatory treatment. These experiments have dealt mostly with some form of sodium aluminate under various trade names, usually supplementary to alum. Results reported in some places are distinctly favorable, but in others the trials have shown no advantage either as to efficiency or cost over the customary treatment.

The repertory of water treatment chemicals is continually increasing. From Elizabeth City, N. C., comes a report of the successful use of chlorinated copperas as a coagulant for a soft, highly colored (550 p.p.m.) swamp water after comparison with alum and sodium aluminate as a primary coagulant. The treatment is carried out by simply feeding chlorine to the copperas solution delivered by a dry-feed machine.

Chlorination.—The chlorination of water has expanded considerably. In addition to the common practice of applying the chlorine in a single dose to the plant effluent, many plants are now making use of split treatment, or application at two points. The practice is not uncommon of treating both raw and filtered water where heavy bacterial loading exists. In this case, application to the raw water is usually referred to as "prechlorination." Hackensack, N. J., is a recent convert to this practice, about 0.5 p.p.m. being used as a primary dose to the inlet of the coagulating basins and a second dose of 0.15 p.p.m. being given to the filter-effluent. At Toledo, Ohio, the filtered water is treated twice to secure satisfactory bacterial results. At Richmond, Va., split or double chlorination is practiced in order to keep down algal growths in a shallow, exposed clear-water basin of considerable area. At Kansas City, Kan., a second application of chlorine is used to control algal growths in a distributing reservoir.

Another important use for chlorine is the so-called superchlorination process whereby an unusually large dose is applied for the purpose either of overcoming extraordinary pollution or of destroying obnoxious substances, such as phenols, which the water supply may contain. This method involves a secondary application of sulfur dioxide or other antichlor for reducing the excess chlorine that would otherwise cause taste. It should be pointed out that superchlorination is directed primarily to the destruction of taste- and odor-producing substances that are not removed by the familiar process of coagulation and filtration. In somewhat the same category, but widely different in principle, are the Cleveland experiments for removing taste and odor by filtration through a special activated carbon.

Softening.—The last few years have witnessed notable additions to the list of softened municipal supplies in this country. Advances in this art have been due to the recarbonation feature which not only obviates incrustation, but results also in effective sterilization and enables more complete softening to be carried out than hitherto possible by the lime-soda process, and at less cost. Simpler and more dependable methods of recarbonation have been developed. The pneumatic system of handling lime, as used at Springfield, Ill., gives promise of modifying the older mechanical-conveyor method.

As regards zeolite softening, there are now seven installations in service for municipal water supplies in this country. With the exception of the 4.0-m.g.d. plant of the Ohio Valley Water Co. at McKees Rocks, the installations are all quite small, ranging from 40,000 to 200,000 gal. per day capacity. However, the extreme hardness of the water handled by some of them is notable.

The 2.0-m.g.d. plant at Sewickly, Pa., now nearing completion, is notable for being constructed along lines of ordinary rapid sand filters. In other words, reinforced concrete replaces the steel-shell construction found in the other municipal installations.

Modified methods of washing and regenerating the zeolite filter have come to the front, but in these it is not easy to distinguish between merit and salesmanship. From the published results, however, it appears that the McKees Rocks plant has succeeded in reducing materially the all-important salt ratio. It is interesting to note that a few industrial zeolite installations are reported to be using sea water or oil-well brine for regeneration.

Conclusion.—The matters that have occupied the attention of water-works people lately are not so much new design features as the modified use of purification facilities already available along the lines of coagulation softening and chlorination. The indications are that treatment of water, instead of being simplified, is becoming more complex and more highly specialized. The standards for hygienic safety have for some years been fairly well met. Now there is beginning to come to the front, more prominently than ever before, the expectation that public water supplies will not only be free from danger to health, but also agreeable in physical properties and reasonably low in hardness or other chemical constituents that affect their use not only by domestic consumers but by industries as well. How else can we interpret the refinements now taken for maximum color reduction, for taste and odor control, and the growing demand for softer water!

E. W. BACHARACH & COMPANY

207 Rialto Bldg., Kansas City, Missouri

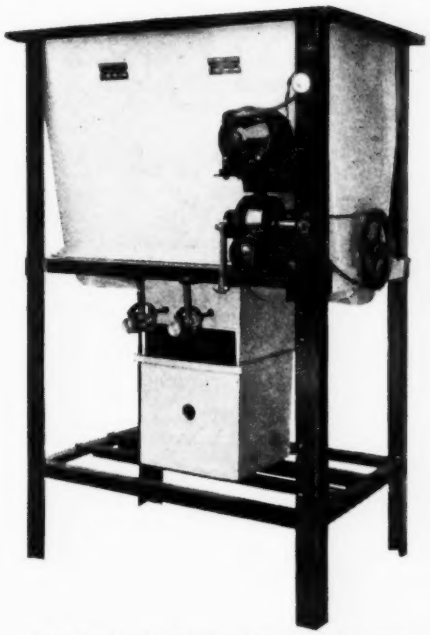
Products: Concrete Gravity Filtration Plant Equipment, Vertical and Horizontal Pressure Filters, Wood Tank Gravity Filters, Iron Removal and Water Softening Plants, Swimming Pool Recirculating-Filtering Systems, Chemical Treating Plant Apparatus.

Kansas City, Mo., 100,000,000 Gal. per day Capacity Filtration Plant

Filtration Plant Equipment: The illustration shows one of the many municipal filtration plants, in which E. W. Bacharach and Company furnished and installed complete equipment consisting of alum manufacturing and treating apparatus, lime slaking and feeding devices, effluent rate controllers, wash water rate controller, operating tables, underdrain systems, filter sand and gravel, chlorinators, venturi meters, loss of head and rate of flow gauges, illuminated dial, and other indicating, recording and integrating gauges, etc.

Chemical Treating Plant Equipment: One of the many types of patented dry chemical feed machines manufactured by E. W. Bacharach and Company is shown in the illustration. It has heretofore been necessary to install a separate dry chemical feeder for each chemical used in a water purification plant. The multiple feed machine involves entirely new principles of operation. This device will accurately feed any number of dry chemicals simultaneously in the same or in different amounts. The machine may also be used to feed several different amounts of the same chemical to separate points of application. The illustration shows a machine built for feeding two chemicals, as for example, lime and alum. The same principle of construction is carried out in building a machine for feeding three or more

Typical Fan-Shaped Swimming Pool



Dry Chemical Feed Machine Multiple Type

chemicals. Some of the advantages of installing a single unit machine that will do the work of a number of individual devices are, reduced initial cost of apparatus, decreased installation expense, saving of space and power, less repairs and depreciation. The multiple machine is built for any capacity and to meet the requirements of any particular installation. It is especially adaptable for use in small and medium sized water purification plants. E. W. Bacharach and Company also build single feed machines and a complete line of chemical solution feed equipment, and will gladly send upon request bulletins, fully describing any kind of water purification plant equipment.

Swimming Pools: Statistics show that in the customary designs of swimming pools, not over 70% of the area is available for persons wishing to stay in the comparatively shallow water, so that the remaining 30% of the pool area is given up to about 10% of the bathers, who dive. The ordinary pool has sharp corners that interfere with circulation so that polluated water is trapped, permitting bacterial growth.

The novel form of fan-shaped pool herewith illustrated is so constructed that the deeper portion is at the narrow end, leaving the greater area for the large majority of persons, who do not dive. All corners are rounded and the shape of the pool is conducive to easy access by life savers. The deep portion is stepped down so that the bottom of the shallow portion need not be constructed at such an acute angle as would be necessary if the declination of the floor was progressively uniform. For any given area, comparatively less material is required in the fan-shaped pool than in one of the forms heretofore used. This unique design is therefore, not only more efficient, but is cheaper to construct. The pool is adaptable for swimming races conforming with the standard regulations of the American Athletic Association. Its odd form blends in with the landscape much better than a rectangular or other conventional design and adds to, rather than detracting from, the beauties of its environment. We have for many years specialized in furnishing and installing complete recirculating filtering and sterilizing equipment for swimming pools. We are prepared to submit plans and specifications for any size of fan-shaped pool to conform with requirements of any State Board of Health or other authority. As we are exclusive licensees to the use of the patent, our customers are protected against any claim of infringement. Further information will be sent upon request, also a list of users of our fan-shaped design of swimming pool and recirculating filtering system.

THE DORR COMPANY, ENGINEERS

Sanitary Engineering Division

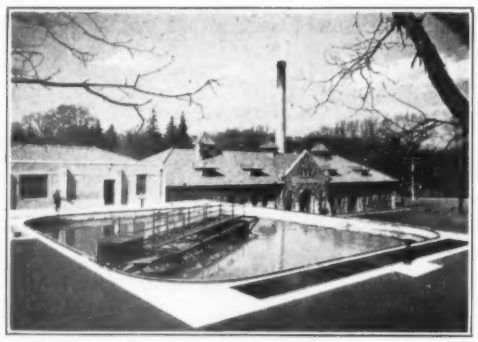
247 Park Avenue, New York

Chicago Toronto Denver Joplin Wilkes-Barre Atlanta Los Angeles

Products: THE DORR WATER CLARIFIER, THE DORR MIXER, DORRCO DIAPHRAGM PUMPS.

The Dorr Water Clarifier: The Dorr Clarifier is a mechanical sedimentation unit, designed to effect a continuous collection and removal of the settleable or precipitated solids, in the form of a sludge, from municipal water supplies.

In water softening plants the Clarifier is installed to remove the precipitated solids before filtration of the water. In the water softening plant at Newark, Ohio, for example, the Dorr Clarifier removes about 98 per cent of the total suspended matter present in the water leaving the mixing chambers, the period of detention in the Clarifier being only 22 minutes.



Dorr Traction Clarifier in the Water Treatment Plant at Mamaroneck, N. Y.

The Clarifier is also used on highly colored water to remove the alum floc or other precipitates before the water enters the settling basins.

Where turbid or muddy waters are the source of supply Dorr Clarifiers are used as pre-sedimentation units to remove the bulk of the suspended solids from the water before chemical treatment. Removal of over 90 per cent of the solids before treatment materially reduces the cost of the chemicals for coagulation. The amount of water lost with the sludge is also greatly reduced.

Advantages: Some of the advantages derived from the use of Dorr Clarifiers in water treatment plants are:

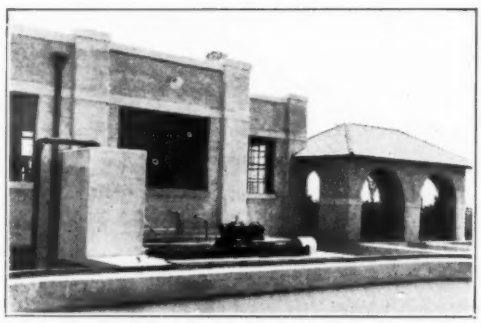
Reduced settling volume required as the sludge storage space is eliminated, thus reducing cost of basin construction. Duplicate units—one in use while the other is being cleaned out—are not necessary, as the Clarifier continuously removes the sludge without draining basin.

The continuous discharge of a small quantity of sludge into the river reduces pollution to a minimum. The intermittent cleaning of old types of basins, when sludge discharge is concentrated, discolors streams for many weeks.

The Clarifier facilitates return of sludge to the mixing basins which encourages the formation of larger flocs, thus increasing the settling rate of the solids.

The action of the clarifier raking mechanism produces a denser sludge than can be obtained by plain sedimentation. Basins may be constructed below ground level as periodical emptying by gravity is not required.

The Dorr Mixer: The Dorr Mixer has been especially developed for use in all cases where chemical "dosing" is required. It is particularly applicable for thorough and efficient mixing of lime, soda ash, alum or other chemicals, with water supplies, previous to sedimentation.



Dorr Mixer in the Water Treatment Plant at Boca Raton, Fla.

Dorrco Diaphragm Pumps: Designed to handle thick heavy sludges. Suction type with gravity discharge, pressure type to work against pressure heads up to 40 feet.

Bulletin: Send for "Sanitary Engineering Bulletin" which describes in detail the uses of Dorr Equipment in water treatment plants.

All Dorr Equipment is protected by patents in U. S. and Foreign Countries.

EVERSON FILTER COMPANY

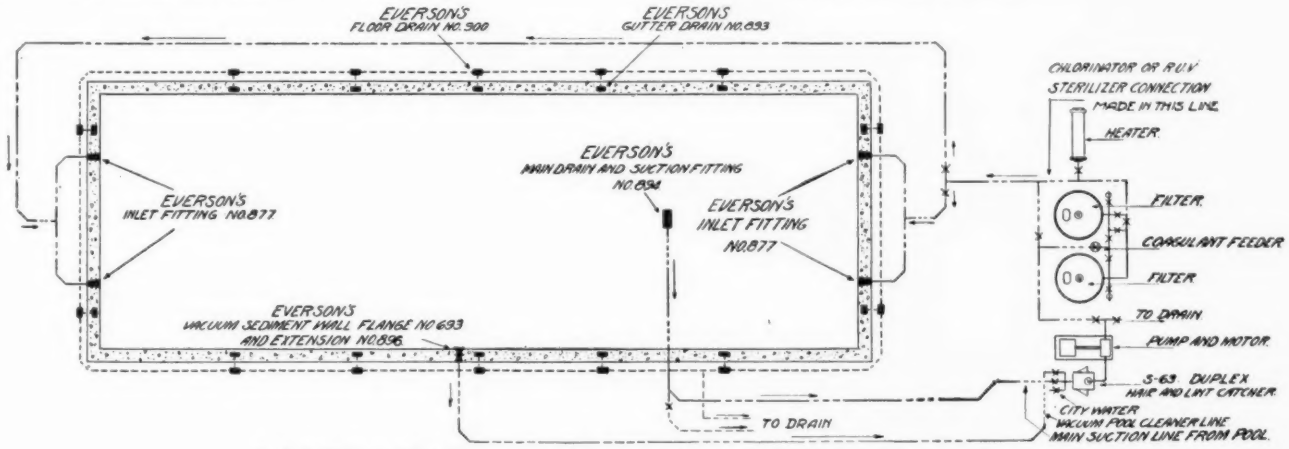
647 N. Green St., Chicago, Ill.

Engineers and Contractors: Swimming Pools, Filtering Systems and Sterlizing Systems

Manufacturers: Filtering Equipment, Water Coolers, Water Softeners, Electric Display Fixtures

Swimming Pools: Designing, engineering and complete construction of all types of swimming pools, including design, manufacture and installation of mechanical equipment for filtration, sterilization and tank cleaning. Contractors for design and manufacture of filtering, purifying and heating equipment only. For over 20 years leading manufacturers of filtering and pool equipment.

Filters for Every Purpose: We manufacture filters, filtering systems and water softening and cooling equipment for public buildings, office buildings, hospitals, hotels—equipment of all sizes, for all purposes. The Everson Eskimo Cooler (a complete drinking fountain unit) is ideal for public places. Everson Zeolite Water Softeners, horizontal or vertical, are exceptionally efficient.


EVERSON'S FLOOR DRAIN NO. 900
EVERSON'S GUTTER DRAIN NO. 693
CHLORINATOR OR R.U.V. STERILIZER CONNECTION MADE IN THIS LINE
HEATER
EVERSON'S MAIN DRAIN AND SUCTION FITTING NO. 894
EVERSON'S INLET FITTING NO. 877
EVERSON'S INLET FITTING NO. 877
FILTER
COAGULANT FEEDER
FILTER
TO DRAIN
PUMP AND MOTOR
3-63 DUPLEX HAIR AND LINT CATCHER
EVERSON'S VACUUM SEDIMENT WALL FLANGE NO. 693 AND EXTENSION NO. 896
TO DRAIN
CITY WATER
VACUUM POOL CLEANER LINE
MAIN SUCTION LINE FROM POOL

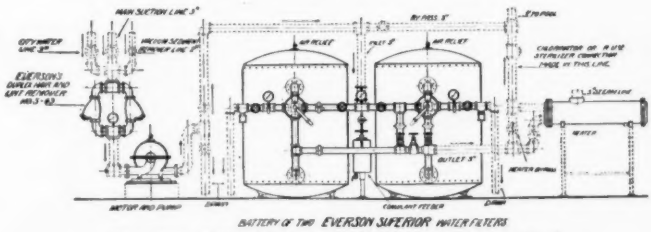
Typical Plan of Equipment for 50,000-Gallon Swimming Pool—20x60 Ft.—12-Hour Turnover

Filtering Equipment for Pools: The Everson Filtering-Clarifying-Purifying System keeps the water crystal clear and pure, free from sediment and germs. A circulating system, operates continuously, minimizes water, water-heating and labor costs. Recommended by health authorities.

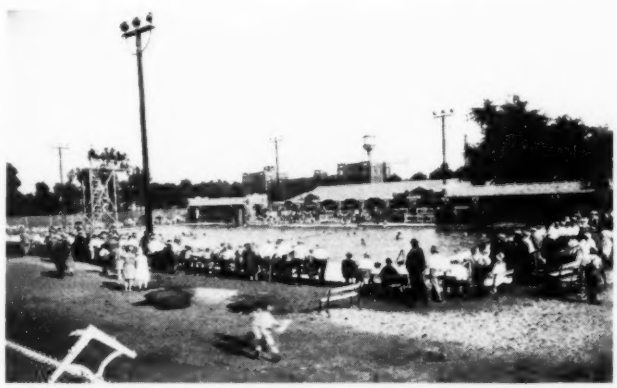
Sold completely installed or units (listed below) can be purchased separately.

Filters	Hair and Lint Catchers
Sterilizers	Inlet Fittings
Pumps and Motors	Drain Fittings
Vacuum Tank Cleaners	Gutter Fittings
Water Heaters	Floor Fittings
	Aerating Nozzles

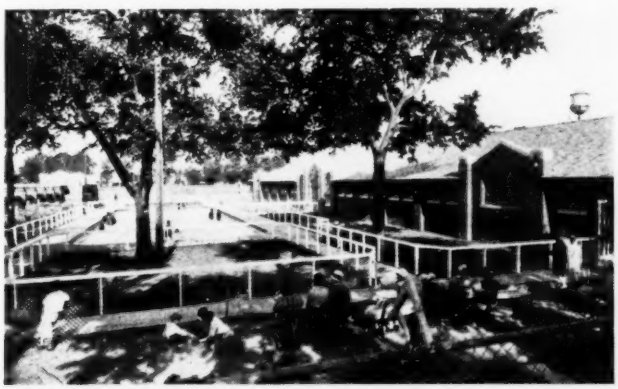
Estimate Service Free: Drawings, specifications, estimates on any complete pool, pool equipment or filtering system will be gladly furnished without cost or obligation. Bulletins and informative circulars, describing our products and complete installations, sent upon request.



Elevation of Mechanical Equipment for Above Pool



Soldiers' Memorial Pool (large pool), Springfield, Ill.



Soldiers' Memorial Pool (small pool), Springfield, Ill.

Miscellaneous Data

Fire Demand

The following tables were abstracted from *Water Works:* The National Board of Fire Underwriters have set forth the following as to requirements to be met for in fire flow:

Table of Required Fire Flow

Population	Required fire flow, gallons per minute, for average city	Population	Required fire flow, gallons per minute, for average city
1,000	1,000	28,000	5,000
2,000	1,500	40,000	6,000
4,000	2,000	60,000	7,000
6,000	2,500	80,000	8,000
10,000	3,000	100,000	9,000
13,000	3,500	125,000	10,000
17,000	4,000	150,000	11,000
22,000	4,500	200,000	12,000

Over 200,000 population 12,000 gal. a minute, with 2,000 to 8,000 additional for a second fire.

Relation Between Domestic and Fire Flows

Population	Required flow for domestic peak G P M	Required flow for fire alone G P M	Size of pipe to deliver Domestic alone, inches	Size of pipe to deliver Fire alone, inches	Size of pipe line Total flow, inches
1,000	173	1,000	4	8 or 10	10
2,000	347	1,500	6	10	12
4,000	694	2,000	8	12	14
6,000	1,042	2,500	10	14	16
10,000	1,736	3,000	12	16	18
13,000	2,257	3,500	14	16	18
17,000	2,951	4,000	16	16	20
22,000	3,819	4,500	16	16	24
28,000	4,860	5,000	16	16	24
40,000	6,944	6,000	18	18	30
60,000	10,416	7,000	24	18	30
80,000	13,888	8,000	30	20	36
100,000	17,360	9,000	30	24	42
125,000	21,700	10,000	36	24	42
150,000	26,040	11,000	42	30	48
200,000	34,780	12,000	42 or 48	30	54

Atmospheric Pressure and Barometer Readings

At Different Altitudes, Approximate Values

From "Compressed Air Data," 1924 Edition

Altitude above sea level feet	Atmos. pressure lb. per sq. in.	Barometer reading inches of mercury	Altitude above sea level feet	Atmos. pressure lb. per sq. in.	Barometer reading inches of mercury
0	14.7	30.0	5,500	11.9	24.3
500	14.4	29.4	6,000	11.7	23.8
1,000	14.2	28.9	6,500	11.5	23.4
1,500	13.9	28.3	7,000	11.2	22.9
2,000	13.6	27.8	7,500	11.0	22.5
2,500	13.4	27.2	8,000	10.8	22.1
3,000	13.1	26.7	8,500	10.5	21.7
3,500	12.9	26.2	9,000	10.4	21.2
4,000	12.6	25.7	9,500	10.2	20.8
4,500	12.4	25.2	10,000	10.0	20.4
5,000	12.1	24.8			

Flow of Water at Plumbing Fixtures

Kind of Fixtures	Fair Flow Per Minute gallons	Good Flow Per Minute gallons	Excellent Flow Per Minute gallons
Kitchen Sink Bibbs	2	4	6
Pantry Sink, High Goose Neck Cocks	2	2	3
Pantry Sink, Large Plain Bibbs	4	6	8
Vegetable Sink Bibbs	2	4	6
Laundry Tray Bibbs	4	6	8
Slop Sink Bibbs	3	4	6
Basin Cocks	2	3	4
Bath Cock (either hot or cold)	3	4	6
Shampoo Spray	½	1	2
Lizer Spray	1	2	3
Shower Baths, 5-in. Rain Heads	2	3	4
Shower Baths, 6½-in. Rain Heads	2	3	5
Shower Baths, 8-in. Rain Heads	4	6	8
8-in. Tubular Shower Heads	6	8	10
Needle Baths	20	30	40
Manicure Tables	1	1½	2

By "Actual test at 30 lb. pressure." Buenger, Journal American Society of Heating and Ventilating Engineers, November, 1920. (See Cosgrove, Principles and Practice of Plumbing, p. 194.)

Joint Materials Required for Water Pipe

For purposes of estimating, we give the following table, which was taken from *Water Works:*

Size of Pipe, In.	Pounds of Jute Per Joint	Pounds of Lead Per Joint	Size of Pipe, In.	Pounds of Jute Per Joint	Pounds of Lead Per Joint
4	0.2	8	12	0.6	22
6	0.3	12	14	0.8	25
8	0.4	14	16	0.9	34
10	0.5	18	18	1.0	36
			20	1.3	40

Leakage from Various Sized Holes

The following was taken from the *Trade Standards of the Compressed Air Society:* The Rock Island System has posted in conspicuous places in the pumping plants and boiler rooms the sign shown below. This sign carries the size of holes of various diameters and gives the amount of leakage together with the financial loss incurred. Probably nothing impresses the average person as does money, and the column showing the direct money loss should cause many a heretofore unnoticed leak to be repaired.

Size of Opening	Air: No. of cu. ft. wasted per month 100 lb. pressure	Air: Total cost of waste per month at 10 ct. per 1,000 cu. ft.	Steam: No. of lb. wasted per month 100 lb. pressure	Steam: Total cost of waste per month at 60 ct. per 1,000 lb.	Water: No. of gal. wasted per month 40 lb. pressure	Water: Total cost of waste per month at 15½ ct. per 1,000 gal.
3/8	9,979,200	$997.92	460,000	$276.00	692,400	$108.00
¼	4,449,600	444.96	203,000	121.80	307,700	48.00
⅛	1,114,560	111.46	50,500	30.30	76,900	12.00
1/16	278,640	27.86	12,750	7.65	19,200	3.00
1/32	69,552	6.96	3,175	1.91	4,800	0.80

Average Depth of Water Mains in Various Cities

From *Water Works:*

	Average Depth, Ft.		Average Depth, Ft.
[1]Akron, O.	5	Manchester, N. H.	5
Albany, N. Y.	5	Miami, Fla.	3
Annapolis, Md.	4	Mobile, Ala.	2
Atlanta, Ga.	3	Montgomery, Ala.	3
Augusta, Ga.	3	Muskogee, Okla.	3½
[2]Beaumont, Texas	3	Nashville, Tenn.	3
Buffalo, N. Y.	5	[4]Newark, O.	5
Charleston, S. C.	2½	Phoenix, Ariz.	3½
Columbus, O.	3½	Richmond, Va.	4
El Paso, Texas	3	[5]Seattle, Wash.	35 in.
[3]Galveston, Texas	2	Shreveport, La.	3½
Holyoke, Mass.	5	Tampa, Fla.	3
Indianapolis, Ind.	4	Trenton, N. J.	4½
Joliet, Ill.	5	Tulsa, Okla.	3–3½
Knoxville, Tenn.	3	Waco, Texas	2
Los Angeles, Cal.	2½	Wheeling, W. Va.	4½
Louisville, Ky.	4	[6]Wilmington, N. C.	2
Macon, Ga.	3–3½		

[1]5 ft. below established grade, except in cases where it is proposed to leave street below grade for time being when minimum cover may be 3 ft.

[2]3 ft. cover for all mains 10 in. and smaller. 4 ft. to 6 ft. cover for mains 12 in. up to and including 24 in.

[3]All new work 2 ft. depth. Old work varies in depth from 2 ft. to 8 ft. as city was filled and only a part of water pipes were raised.

[4]Trench 5 ft. deep.

[5]6 in. to 8 in., 35 in. below mean curb grades; 10 in., 40 in., 12 in., 43 in.; larger sizes up to 30 in., 36 in.

[6]4 in. cast iron mains, 2 ft. cover; 6 in. and 8 in., 30 in. cover, 12 in., and over 36 in. cover.

Water Mains on Per Capita Basis

The following data were taken from *Water Works:*

A comparison of 12 cities of the United States with respect to the number of feet of water mains on a per capita basis is shown in the following table:

Year	City	Population	Total Feet of Mains	Feet Per Capita	Relative Density of Population
1920	St. Paul	234,000	2,399,000	10.3	1.33
1920	Erie, Pa.	93,000	917,000	9.9	3.70
1920	Springfield, Mass.	129,000	1,249,000	9.7	1.00
1921	Providence	237,000	2,270,000	9.6	4.00
1920	Toledo	243,000	2,261,000	9.3	2.36
1919	Louisville	234,000	2,182,000	9.3	2.75
1920	Columbus	237,000	1,878,000	7.9	3.20
1920	Detroit	994,000	7,222,000	7.3	4.10
1920	Cleveland	797,000	5,478,000	6.9	4.35
1920	St. Louis	773,000	5,350,000	6.9	3.90
1920	Milwaukee	465,000	2,906,000	6.3	5.50
1922	Cambridge	115,000	695,000	6.0	5.10
Totals and Average		4,551,000	34,807,000	7.6	

The average density of population of the above 12 cities is 10,700 per square mile and the average number of feet of pipe per square mile is 81,500.

Water Drawn at Fixtures (Estimated)

Fixture	Rate of Flow, Gallons Per Minute	Fixture	Rate of Flow, Gallons Per Minute
Bath	10	Shower	5
Lavatory	5	Sink	10
Tank Closet	5	Laundry Tub	10
Valve Closet	30	Garden Hose	10

Copper and Brass Research Association (Sweet's Catalogue, p. 1457, 17th edition, 1922).

Selection of Filter Sands

Physical and chemical requirements, sources of supply, methods of handling and approximate costs of good filter sand were given by W. M. Weigel, Mineral Technologist, Bureau of Mines, Department of the Interior, Washington, D. C., in *Water Works:*

Most cities of any size that draw their water supply from surface sources use sand filters in their purification system. Not only are sand filters employed to remove sediment and suspended matter, but they also take out most of the bacteria in the water.

The first comprehensive research and study of sand for this purpose was probably that of Hazen for the Massachusetts Board of Health in 1891 and 1892,[1] although sand filters had been employed for a considerable time before. Specifications for filter sand drawn since then have been largely based on the results of Hazen's work.

Requirements.—The general requirements for filter sand are more exacting than for any of the different kinds of sand, except the chemical specifications for glass sand. Filter sand must be uniform in size and within certain limiting sizes. In addition, it must be clean and free from clay and organic matter and of fairly high purity. Early investigations established the fact that an excess of fine material increased the friction and decreased the rate of flow through the filter, and that the size of the finer particles rather than the coarser, determined the effective size. Also, that large grains tended to cause irregularities in flow in different parts of the bed. There is no requirement as to grain shapes, except that they be not flat or elongated, since, so far as known, either rounded or angular grains are equally efficient.

"Effective Size" and "Uniformity Coefficient."—Based on Hazen's investigations, two factors are quite generally used to control the average size and uniformity of size of the sand. These are defined as follows: The "effective size" of a sand is such that 10 per cent by weight of the sand is finer than this size, and 90 per cent is coarser. It is expressed in millimeters. The "uniformity coefficient" is defined as the ratio of the size of grain which has 60 per cent finer than this size to the size which which has 10 per cent finer (the "effective size"). It is evident that the smaller this coefficient, the more uniform is the sand. If all the grains were exactly the same size, the coefficient would be 1.

The ordinary method of determining the effective size and uniformity coefficient, is to make a screen analysis of the dry sand. The cumulative percentages are then plotted against the size of the screen openings. The intersection of the curve with the 90 per cent line gives the effective size, that is, 10 per cent is finer than this. The size corresponding to the 40 per cent value (60 per cent is finer than this), is read from the plot and this divided by the effective size gives the uniformity coefficient. The use of co-ordinate paper, in which percentages are laid off on the vertical axis numerically and the logarithms of the sizes of screen openings along the horizontal, makes a convenient form. Printed blank forms ruled in this way may be obtained from the manufacturers of testing sieves. This method, in reality, represents the size of opening through which the grains will pass, or on which they are retained, rather than the actual grain size. Before accurate screens were obtainable, it was customary to determine the size of grains passing a given screen by collecting the last grains passing and then by counting a known weight of these and, their specific gravity, being known, their diameters assumed as spheres could be calculated.

Specifications usually state, in addition, that no grains shall be larger than a certain mesh and also limit the percentage of every fine material, or that which will pass a 100-mesh sieve, as during the washing with countercurrent flow, the fines collect in the top part of the sand bed and clog the filter.

Sands with effective sizes of 0.20 to 0.70 mm. are used, but those most commonly specified have effective sizes from 0.40 to 0.50 mm. The uniformity coefficient varies from 1.25 to 1.80 with 1.55 to 1.60 as an average.

The following table gives the effective size and uniformity coefficient of samples supplied by some regular producers of filter sand. Tyler standard testing sieves were used in making the analysis.

Sample No.	Source	Effective Size	Uniformity Coefficient
322	New Jersey	0.43	1.40
328	New Jersey	0.38	1.42
329	New Jersey	0.60	1.33
337	New Jersey	0.41	1.39
338	North Carolina	0.38	1.67
345	Illinois	0.42	1.26
348	Minnesota	0.33	1.60
349	Minnesota	0.44	1.52
350	Minnesota	0.37	1.55

Chemical Analysis.—A good filter sand requires a rather high silica content. It is generally specified that not more than 2 per cent shall be soluble in hot dilute hydrochloric acid. Other specifications state that the combined brine and magnesia calculated as carbonates shall not exceed 2 per cent. Aside from this, the chemical composition is usually not specified.

Specifications.—Some condensed specifications are as follows:

Water Department, Baltimore, Md., Filtration Division, Contract No. 22, provides that:

The sand shall be composed of hard and durable grains, either sharp or rounded, substantially free from clay, loam, dust or other foreign matter and flat particles.

When crushed and powdered and digested for 24 hours in strong, warm, hydrochloric acid, without stirring, at least 95 per cent shall remain insoluble. The sand shall not contain more than 2 per cent of calcium and magnesium taken together and calculated as carbonate.

The stock sand furnished shall have an effective size of not less than 0.33 mm. and a uniformity coefficient of about 1.75. At least 90 per cent shall be finer than 2 mm. After being placed and washed (as specified) and the fine sand on top scraped off and removed and the sand rewashed, the top two inches shall have an effective size between 0.40 and 0.50 mm. and not more than 1 per cent shall be finer than 0.25. The diameters of the sand grains shall be computed as the diameters of spheres of equal volumes and all percentages shall be calculated by weight.

The Baltimore Water Department states that, with new work, they would use a little coarser sand, and expect in that way to get better results.

Washington, D. C., specifications provide that:

Sand shall be clean river, beach, or bank sand, either sharp or rounded, entirely free from clay, dust or organic impurities.

Not more than 0.5 per cent shall be less than 0.13 mm; not more than 8 per cent less than 0.26 mm. At least 7 per cent shall be less than 0.34 mm, at least 70 per cent less than 0.83 and at least 90 per cent less than 2.1 mm. No particle shall be less than 5 mm. diameter. The sand shall not contain more than 2 per cent of lime and magnesia calculated as carbonate.

Springfield, Mass., and Toronto, Ont., have general specifications that are the same as those for Washington. Size limits are as follows: The effective size shall not be less than 0.25 mm. nor more than 0.35 mm. The uniformity coefficient shall not be less than 3.0. The sand shall be free from dust and shall not contain more than 1 per cent finer than 0.13 mm. and entirely free from all particles over 5 mm.

A Missouri plant prepares its sand to the following specifications: Effective size not less than 0.40 nor more than 0.50 mm. and uniformity coefficient not greater than 1.65. Not more than 0.25 per cent shall be finer than 0.25 mm. At least 95 per cent shall be finer than 1.2 mm.

Sources of Supply.—Compared with building sand, the production of filter sand is small and requires more careful preparation and extensive plant. A much better price is obtained than for the ordinary grades of sand, and in consequence the points of production are more widely scattered and the sand is sometimes shipped long distances.

The chief producers are in New Jersey, North Carolina, Illinois, Minnesota and Missouri, but any good sand bed can produce suitable filter sand, if it can be washed clean and contains enough grains of the required size to warrant their

[1]Report of the Masschusetts Board of Health, 1892, p. 541.

separation from the rest of the sand. Where the coarser grades of sand-blast sand are produced, the finer material is often prepared for filter sand. Also, the finer grades of sand-blast sand[2] may be used for filter sand if prepared with proper uniformity.

Method of Mining.—Filter sand may be prepared from ocean beaches, lake deposits, river bars, sand banks and soft sandstone, and the method of excavation depends largely on the nature of the deposit.

Where beach sand is used, the excavation is above high tide, so floating dredges are not feasible. Also, the area excavated usually has considerable horizontal extent so that excavating machines are best mounted on railroad track paralleling the direction of the beach. Locomotive cranes with clamshell buckets make about the most efficient equipment; they have a wide reach and are more suited to the comparatively shallow excavations than steam shovels. The sand is conveyed to the washing and screening plant, preferably in side dump cars drawn by steam or gasoline locomotive.

Sand in lake shores and bottoms and river bars is commonly excavated with dredging pumps mounted on barges. They give very mobile, efficient units. Sand can be pumped from any desired part of the bed, and enough water is at the same time pumped for washing or at least most of the washing. The mixture of sand and water is also conveyed to the plant through pipe lines in the same operation, within reasonable distances, and the action of the pump impellers tends to break up any clay lumps and facilitate washing. If the sand is to be conveyed some distance in cars, clamshell dredges sitting on the bank of the lake and loading into cars alongside, are sometimes used, as the power cost is less than for a dredge pump.

When an artificial pond can be maintained, floating dredges are often the most efficient means of excavating the sand from what would otherwise be dry banks. If stripping of overburden is necessary, it is done by hand, scrapers, or steam shovel and the overburden hauled away in wagons or motor trucks. Sometimes, the overburden is back-filled into the excavation. The floating dredges have steam, electric or oil engines, depending on which form of power is cheapest and best suited to the conditions.

Dry sand banks are mined with steam shovels if the plant capacity is sufficient to warrant their use, otherwise the cars or wagons are loaded by hand. Practically all regular producers of filter sand, however, have operations large enough to warrant the use of mechanical excavators.

Soft, friable sandstone constitutes most of the source of filter sand in the Mississippi Valley district. This sand is characterized by uniformly rounded grains, in this way differing from the angular to irregular surfaced grains from lakes and banks. Some river sand also is mined in this territory.[3]

The excavation of sandstone for sand has been briefly described by the writer in Bureau of Mines Serial No. 2615, "Sand Blast Sand."

[2]Weigel, W. M., sand blast sand, Serial 2615, Bureau of Mines, June, 1923.

[3]Dake, C. L. Sand and Gravel Resources of Missouri, No. Bureau of Geol. and Mines, Vol. XVI, 2nd Series, p. 76.

Preparation.—Preparation of filter sand involves washing or screening and usually a combination of both. Very few sands are clean enough without washing. These processes have been outlined in the report on Sand Blast Sand mentioned above, as some firms produce both sand blast and filter sand from the same bed or bank.

For filter sand, the specifications as to size and uniformity is rigid, so that careful screening or sizing is essential. In some instances, the sand is re-screened to insure the removal of fines.

Sizing by screens is almost universal, but where an ample water supply is available, it would seem that hydraulic classification should give a suitable product, as all grain are of the same specific gravity and roughly, of the same shape. It is admitted that more careful supervision would be needed than in sizing by screens, but that should be more than offset by lower first cost or greater capacity, and the washing and sizing would be performed in one operation. The sand originally used for the Washington, D. C., filtration plant was prepared by combined screening and hydraulic classification.[4]

The sand bank used contained considerable clay in the form of lumps and seams that could not be rejected in mining, making removal of the clay necessary. The sand from the bank was first dumped through a coarse grating to remove the larger clay lumps. This was followed by a revolving screen with 2-inch openings. The sand then passed through a revolving screen with 4 mm. openings in which jets of water played. The water and solids passing through this screen flowed to pug mills, which broke up and pulverized the remaining clay lumps. An excess of water here overflowed and removed a good portion of the clay. The sand was drawn out near the bottom. The pug mill was followed by the washers, which were long boxes with sloping bottoms, the feed entering at the shallow end. Water supply pipes near the bottom had perforations pointing downward. The overflow of clay and water was removed by a central trough. The sand, after being separated from the clay by the combined horizontal and upward currents of water, was drawn off at the bottom of the deeper end of the washer. The capacity was stated to be about 1 cubic yard per hour per square foot of box area.

[4]Hazen, Allen, and Hardy, E. D., Water Filtration at Washington, D. C., Trans. Am. Soc. Civil Eng., Vol. LVII, p. 326.

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Analysis of Filter Sands, by Allen Hazen, Engineering Record, Vol. XXXV, p. 163.

Water Filtration at Washington, by Hazen & Hardy, Trans. Amer. Soc. Civil Engineering, Vol. LVII, p. 326.

Economy Effected in Use of River Sand as Filter Medium at Moline, Ill., Engineering and Contracting, Vol. 43, p. 236.

THE COLUMBIA SILICA COMPANY

Akron, Ohio

Silica Sand and Sand Blast Sand

Chicago Office: A. S. Hindman, 1221 First National Bank Bldg., Chicago, Ill.

Products: FILTERING SAND, SILICA SAND, GROUND SILICA, FLINT SAND, BLAST SAND, ASPHALT SAND, CEMENT SAND, FOUNDRY SAND.

Columbia Sand is an effective filtering medium for filtration plants as has been shown by its use by a number of municipalities. It also is used extensively by filter manufacturers for smaller plants and for swimming pools, industries, public buildings, schools and homes.

Method of Production: The Columbia Silica Company own a 60 acre tract of Silica Deposit, located at Copley, Ohio, a suburb of Akron, Ohio. The deposit is cliff and below surface to a height of approximately 50 feet.

The cliff is first blasted, then a separation is made of the sands and pebbles after which they are run through washers to remove any foreign substances.

Pebbles are run through screens after washed and all moisture is then removed by driers which have a capacity of 50 tons per hour. All material is handled by belt conveyors and elevators.

The smaller mesh of quartz is prepared by crushers and all extreme fines are removed by dust arresters and separated as to mesh into storage bins, seven of which have a capacity of 300 tons each.

Sizes of Gravel are: 1¼ to ¾, ¾ to ⅜, ⅜ to ¼ and ¼ to $\frac{8}{32}$.

The finer mesh is as follows and carry our symbol numbers as shown.

No.	Passing	Thru	Retaining	On
1	2½	.120	3½	.092 Wire Screen
2	3½	.092	4½	.072 Wire Screen
3	4½	.072	7	.054 Wire Screen
4	7	.054	10	.035 Wire Screen
5	10	.035	14	.028 Wire Screen
6	14	.028	20	

These grades No. 1 to No. 6 inclusive are angular in form and used extensively in Pressure Filtration.

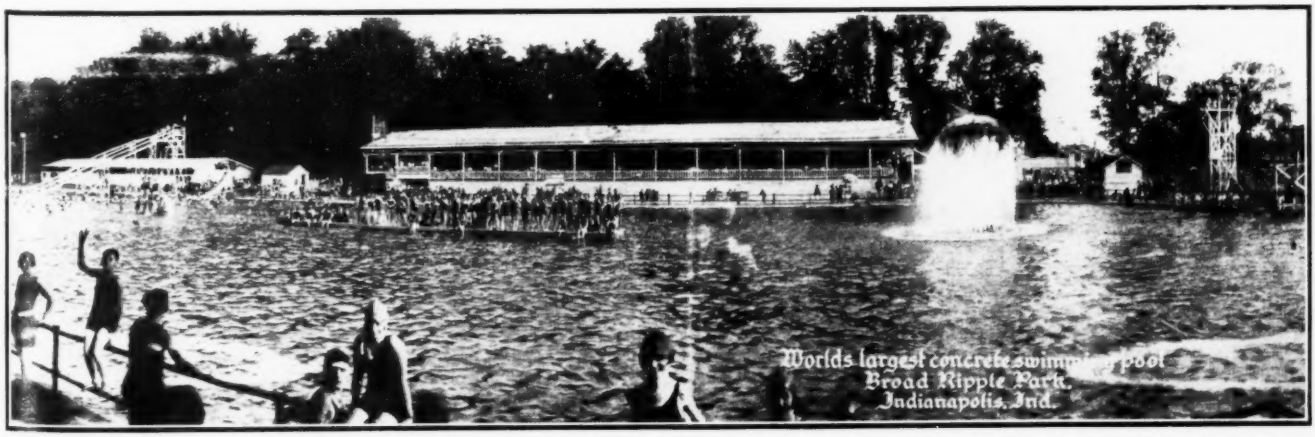
TEST: Pittsburgh Testing Laboratory of Pittsburgh report material 98.85% Pure Silica Quartz.

A few users of Columbia Pure Silica Quartz:

Swimming Pools, Municipal, Public Schools, Paper Manufacturing Plants, etc.

South Bend, Ind.
Indianapolis, Ind.
Illinois Athletic Club, Chicago, Ill.
Franklin, Ind.
Y. M. C. A., Springfield, Ill.
Broad Ripple Park, Ind.
Ashland, O.
City of Chicago Public Schools (Portion).
Kankakee, Ill.
Canton, O.
Cleveland, O.
Pontiac, Mich., Public Schools.
Mount Hope, W. Va.
Koppers Company.
Commonwealth Edison Co.

Send for samples and quotations.



Worlds Largest Concrete Swimming Pool, Broad Ripple Park, Indianapolis, Ind. Equipped with Perkins Purification System using Columbia Pure Silica Quartz, which changes water daily and assures the public pure drinking water to bathe in.

Graphical Chemistry in Water Softening

The following methods for calculation of analytical values and quantities of chemical reagents used in standard lime and soda ash processes were described by R. L. McNamee, principal assistant engineer, Hoad, Decker, Shoecraft & Drury, consulting engineers, Ann Arbor, Mich., in *Water Works:*

In several years' experience in the study of public water supplies, particularly among the hard ground waters of the region of the Great Lakes, the problem of calculating the measure of hardness and estimating the necessary dosage of softening chemicals has often presented itself. The variety of forms in which water analyses are stated by different analysts involves the problem of calculation. To one not constantly engaged in this work, the recollection or computation of conversion factors is a tedious and sometime uncertain process. In order to simplify these calculations the data have been arranged in the form of nomographic or alignment charts, which are reproduced herewith.

Soap Requirements.—In "The Value of Pure Water," by the late Professor George C. Whipple, there is a very interesting tabulation of the quantities of several commercial brands of soap consumed by various degrees of hardness in water. These data have often served to bring home to the layman one phase of the economic value of water softening to the domestic consumer. A convenient form for these data is given in Fig. 1, an alignment chart in which the intercepts of a straight line on all three scales give related values of the hardness, quantity and brand of soap.

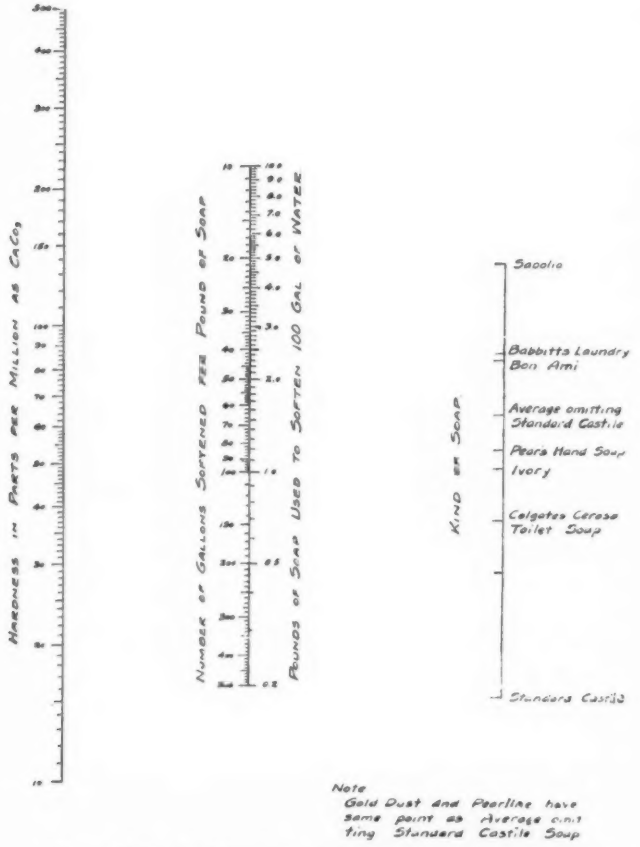

Hardness in Parts per Million as $CaCO_3$
Number of Gallons Softened per Pound of Soap
Pounds of Soap Used to Soften 100 Gal. of Water
Kind of Soap
Sacolic
Babbitts Laundry
Bon Ami
Average omitting Standard Castile
Pears Hand Soap
Ivory
Colgates Cerose Toilet Soap
Standard Castile
Note
Gold Dust and Pearline have same point as Average omitting Standard Castile Soap

Fig. 1—Soap Requirements for Waters of Various Hardness

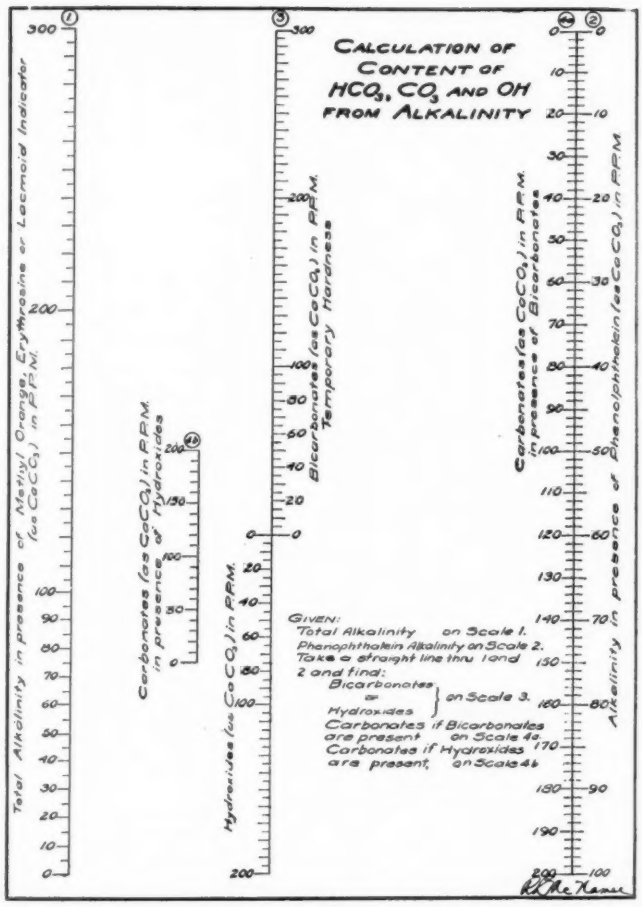

Calculation of Content of HCO_3, CO_3 and OH from Alkalinity
Total Alkalinity in presence of Methyl Orange, Erythrosine or Lacmoid Indicator (as $CaCO_3$) in P.P.M.
Carbonates (as $CaCO_3$) in P.P.M. in presence of Hydroxides
Hydroxides (as $CaCO_3$) in P.P.M.
Bicarbonates (as $CaCO_3$) in P.P.M. Temporary Hardness
Carbonates (as $CaCO_3$) in P.P.M. in presence of Bicarbonates
Alkalinity in presence of Phenolphthalein (as $CaCO_3$) in P.P.M.
Given:
Total Alkalinity on Scale 1.
Phenophthalein Alkalinity on Scale 2.
Take a straight line thru 1 and 2 and find:
Bicarbonates or Hydroxides } on Scale 3.
Carbonates if Bicarbonates are present on Scale 4a
Carbonates if Hydroxides are present on Scale 4b
R. L. McNamee

Fig. 2—Calculation of Content of HCO_3, CO_3 and OH from Alkalinity

Determination of Temporary Hardness.—The alkalinity as determined by phenolphthalein and as determined by methyl orange, erythrosine or lacmoid, are often the only reported values given in an analysis which are of any value in estimating the hardness. The fundamental relations between these alkalinity determinations and the corresponding values of the bicarbonate, carbonate and hydroxide radicals are graphically represented in Fig. 2. With only these data given, the temporary hardness alone may be determined.

Calculation of Degree of Hardness.—When the analyses state the values of the calcium, magnesium and bicarbonate radicals, the calculation of the degree of hardness and the required amounts of lime and soda ash necessary for softening is simply a problem of conversion. Fig. 3 is a graphical statement of the relations necessary for the solution of the problem. The calcium (Scale 1), and magnesium present (Scale 2) measure approximately the total hardness (Scale 3). (Iron and certain other radicals are sometimes present and contribute to the hardness, but to such slight extent that they are usually ignored.) The bicarbonate radical (Scale 4) is a measure of the temporary hardness. The difference between the total hardness and the temporary hardness is the permanent hardness (Scale 5), which in turn measures the required amount of soda ash (on the opposite side of the Scale 5). The required amount of lime (Scale 6) is given by the intercept of a straight line connecting the values of magnesium (Scale 2) and bicarbonate (Scale 4).

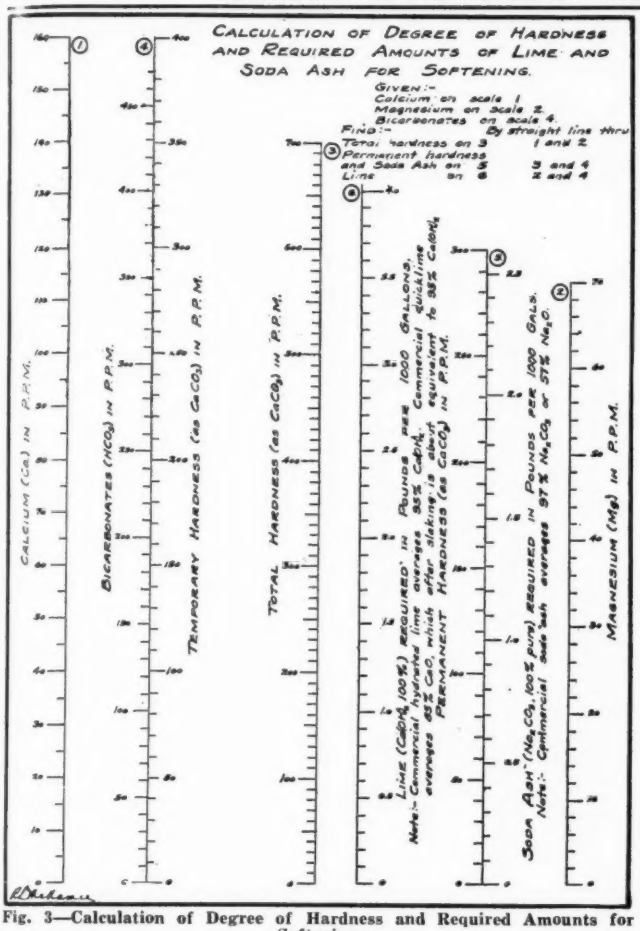

CALCULATION OF DEGREE OF HARDNESS AND REQUIRED AMOUNTS OF LIME AND SODA ASH FOR SOFTENING.
GIVEN:- Calcium on scale 1, Magnesium on scale 2, Bicarbonates on scale 4.
FIND:- Total hardness on 3 by straight line thru 1 and 2
Permanent hardness and Soda Ash on 5 3 and 4
Lime on 6 2 and 4
CALCIUM (Ca) IN P.P.M.
BICARBONATES (HCO_3) IN P.P.M.
TEMPORARY HARDNESS (as $CaCO_3$) IN P.P.M.
TOTAL HARDNESS (as $CaCO_3$) IN P.P.M.
LIME (CaO)(95%) REQUIRED IN POUNDS PER 1000 GALLONS. Note:- Commercial hydrated lime averages 95% CaO, which after slaking is equivalent to 85% CaO averages 85% CaO, which after slaking is about equivalent to 88% CaO in P.P.M.
PERMANENT HARDNESS (as $CaCO_3$) IN P.P.M.
SODA ASH (Na_2CO_3)(100% pure) REQUIRED IN POUNDS PER 1000 GALS. Note:- Commercial soda ash averages 97% Na_2CO_3 or 57% Na_2O.
MAGNESIUM (Mg) IN P.P.M.

Fig. 3—Calculation of Degree of Hardness and Required Amounts for Softening

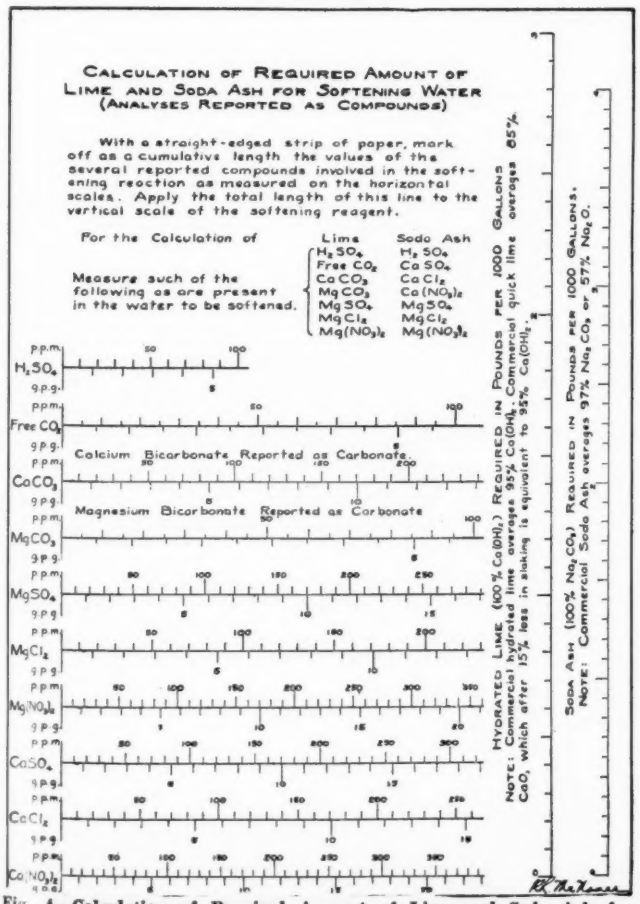

CALCULATION OF REQUIRED AMOUNT OF LIME AND SODA ASH FOR SOFTENING WATER (ANALYSES REPORTED AS COMPOUNDS)
With a straight-edged strip of paper, mark off as a cumulative length the values of the several reported compounds involved in the softening reaction as measured on the horizontal scales. Apply the total length of this line to the vertical scale of the softening reagent.
For the Calculation of
Measure such of the following as are present in the water to be softened.
Lime: H_2SO_4, Free CO_2, $CaCO_3$, $MgCO_3$, $MgSO_4$, $MgCl_2$, $Mg(NO_3)_2$
Soda Ash: H_2SO_4, $CaSO_4$, $CaCl_2$, $Ca(NO_3)_2$, $MgSO_4$, $MgCl_2$, $Mg(NO_3)_2$
Calcium Bicarbonate Reported as Carbonate
Magnesium Bicarbonate Reported as Carbonate
HYDRATED LIME (100% $Ca(OH)_2$) REQUIRED IN POUNDS PER 1000 GALLONS
NOTE: Commercial hydrated lime averages 95% $Ca(OH)_2$. Commercial quick lime averages 85% CaO, which after 15% loss in slaking is equivalent to 95% $Ca(OH)_2$.
SODA ASH (100% Na_2CO_3) REQUIRED IN POUNDS PER 1000 GALLONS.
NOTE: Commercial Soda Ash averages 97% Na_2CO_3 or 57% Na_2O.

Fig. 4—Calculation of Required Amount of Lime and Soda Ash for Softening Water

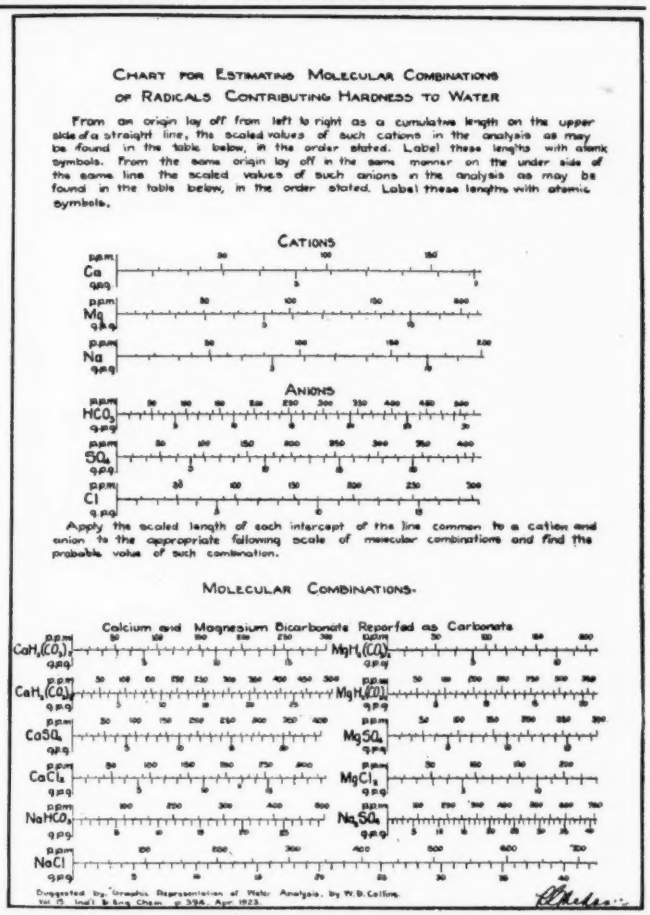


CHART FOR ESTIMATING MOLECULAR COMBINATIONS OF RADICALS CONTRIBUTING HARDNESS TO WATER
From an origin lay off from left to right as a cumulative length on the upper side of a straight line, the scaled values of such cations in the analysis as may be found in the table below, in the order stated. Label these lengths with atomic symbols. From the same origin lay off in the same manner on the under side of the same line the scaled values of such anions in the analysis as may be found in the table below, in the order stated. Label these lengths with atomic symbols.
CATIONS
Ca
Mg
Na
ANIONS
HCO_3
SO_4
Cl
Apply the scaled length of each intercept of the line common to a cation and anion to the appropriate following scale of molecular combinations and find the probable value of such combination.
MOLECULAR COMBINATIONS.
Calcium and Magnesium Bicarbonate Reported as Carbonate
$CaH_2(CO_3)_2$
$MgH_2(CO_3)_2$
$CaCO_3$
$MgCO_3$
$CaSO_4$
$MgSO_4$
$CaCl_2$
$MgCl_2$
$NaHCO_3$
Na_2SO_4
NaCl
Suggested by Graphic Representation of Water Analysis, by W. D. Collins, Vol. 15, Ind. & Eng. Chem., p. 334, Apr. 1923.

Fig. 5—Chart for Estimating Molecular Combination of Radicals Contributing Hardness to Water

Lime and Soda Ash Dosage.—When the analyses state values in the molecular form, the calculation of the required amounts of lime and soda ash for softening necessitates the use of molecular weights and equations of reactions, data usually not readily available in the field. Fig. 4 is a yardstick for lime and soda ash dosage. Lengths measured by values of reacting compounds applied cumulatively to the scales of the softening reagents give the quantities required.

In Figs. 3 and 4, the resulting values for lime and soda ash are stated as 100 per cent reagent, and notes are given concerning the strength of commercial chemicals. The investigator should divide the indicated results by the percentage factor for the chemical commercially available for softening.

Estimating Molecular Combinations.—When the analyses state the values in the atomic or radical form, it is frequently desired to know the probable molecular combinations actually present. Mr. W. D. Collins in Volume 15 of "Industrial and Engineering Chemistry" for April, 1923, has suggested a method for approximating these data. Figure 5 is based upon the method suggested by Mr. Collins and carries the computation to a numerical estimate of the molecular values.

The foregoing alignment charts may be found helpful in assisting in the solution of the many problems which are encountered in water analysis and water softening investigations. Their general value will be in relieving the user of the necessity for searching out conversion factors and reacting ratios.

Chlorine in the Fields of Sanitation

PART I

Water Chlorination

The following information was prepared by L. H. Enslow, Research Engineer, Chlorine Institute, Inc.:

The technique of water chlorination at times requires two other gases, sulphur dioxide and ammonia. We cannot at this time foresee the use of oxygen, hydrogen, and acetylene, but as water and sewage problems become more complicated, as they do, anything is possible.

The growth of water chlorination, since its beginning less than 20 years ago, has been phenomenal. Not less than 90,000,000 people in over 6,000 communities are supplied with water rendered safe by chlorine.

Progress in Water Chlorination.—Perfected methods for so-called "free chlorine" determinations by Ellms and Hauser[2] and the subsequent adaptation of the "free chlorine" test in 1918 by Wolman and Enslow[3] provided means of scientific regulation of chlorine dosage. The newer method of control was based on the addition of sufficient chlorine to satisfy the "chlorine demand" and leave some "residual chlorine" in the treated water after a short period of reaction. This proved to be of paramount importance in making chlorination dependable under a great variety of circumstances. Without proper control, chlorination is either overdone or affords only false security. Within the year (1928) failure to regulate the chlorine dosage by making daily tests for residual chlorine resulted in a typhoid epidemic at a small city in New York State. Use of the test would have disclosed the sudden increase of chlorine demand due to the accidental gross pollution of the water supply.

Prechlorination.—One, if not the earliest, to advocate a raw water chlorination to reduce the bacterial load on sand filters and the expenditure for coagulant was N. J. Howard of Toronto,[4,5] where prechlorination has been effectively practiced with a material saving in coagulant for a number of years. It is only within the past two years that prechlorination has received any marked impetus in the United States. This progress is recounted in recent papers by the writer.[1,7]

Aside from the value in reducing the bacteria and rendering additional safety, prechlorination possesses, among others, the following merits:

(a) Allows reduction of residual chlorine carried in finished waters.

(b) Algae growths controlled in basins and filter beds.

(c) Longer filter runs between washings and less wash water required.

(d) Reduction of coagulant dosage in certain instances.

(e) Reduction of "slime" on sand grains and consequent less trouble with mud balls and cracked filter beds. More sparkling effluent results.[12]

(f) Reduced tendency for sludge in coagulation basins to putrefy or lift to the surface as a result of gasification. More palatable water results.

Super- and Dechlorination.—Superchlorination followed by dechlorination was inaugurated at Toronto in the fall of 1926. It was later discontinued, but recurrence of tastes justified resumption of the process in June, 1927, since which time it has continued with success.

The procedure consists of dosing the filtered water with 0.8 to 2.5 parts per million chlorine, the maximum being required in coldest weather. A contact period of approximately one hour is thereafter available in the filtered water collection basin and tunnel delivering to the high pressure pumping station. At this station all excess "residual" chlorine is destroyed by application of sulphur dioxide fed through Wallace and Tiernan "sulfonators" connected to cylinders containing liquefied sulphur dioxide. Excess sulphur dioxide has no deleterious effects, but to insure greatest economy, the plant is operated by simple control tests which indicate that the excess chlorine has been completely destroyed without waste of sulphur dioxide. The superchlorination process is not continuously operated. Laboratory tests on the lake water indicate ahead what to expect in the matter of taste troubles, and only during periods that these tests indicate superchlorination essential is the process used.

The operating cost during use of the process is increased by roughly 78 ct. per million (Imperial) gallons. Normally the cost of ordinary chlorination is 96 ct. per million gallons. Introduction of chlorine in one-ton containers as planned will reduce the chlorine cost to one-half that on which the above figure is based.[1,9]

Other Taste Prevention Measures.—In England, Sir Alexander Houston has again led the way in the field of chlorination by developing and successfully applying the preammoniation and premanganate treatments to prevent taste production in chlorinated waters.[10]

Pre-Ammoniation.—The process consists of application of an ammonia salt or ammonia water sufficient to provide 0.25 ppm. available ammonia (NH_3). In America the ammonia water is prepared at the point of application from anhydrous ammonia. Following the ammonia application chlorine is applied. The supposition is that chloramines are formed which do not subsequently develop taste producing compounds. Regardless of the theories, it seems to be a proven fact that tastes are prevented by preammoniation. In America the process has been employed with success at Greeneville, Tenn., for the past three years.[11] At Springfield, Ill., the process was introduced in February, 1928, and continues to render chlorination non-taste producing.*

Permanganization.—This process consists of application of potassium permanganate ($KMnO_4$) crystals in conjunction with the chlorination. Sir Alexander Houston points out that permanganate may be applied ahead of, immediately at, or beyond the chlorine application with equal efficiency. To certain waters he applies ammonia prior to chlorination continuously and in addition permanganate is at times also applied at the chlorination stations, if there is any evidence of likelihood of taste production. In America the permanganization process is applied either continuously or intermittently at Rochester, N. Y., and Buffalo, N. Y., with success. The point of application is slightly in advance of chlorination. The dosage at Rochester varies between 0.05 (median) to 0.14 (maximum). At Buffalo the dosage has been varied considerably to meet the demand, but an average of 0.03 ppm. is employed for the most part.[1]

Chlorine in Algae Control.—Much of the water supplied Greater New York is chlorinated three times during its travel from its point of origin to the city. As the water is progressively chlorinated during its passage from one

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reservoir to another, evidence is available to show the material value of the chlorine in reduction of algae growths in these reservoirs, in which previously an increased growth had been observed. In addition to its value in controlling algae growth it has been successfully used to destroy synura, asterionella, tabellaria, anabaena, volvox, melosira, ceratium, aphanizomenon and coelosphaerium in the New York water supply. It seems that 0.5 ppm. residual chlorine will destroy practically all of the objectionable forms of algae and most of them succumb to 0.2 ppm.[1,7,13,14]

Very recently chlorination has been found effective in killing "water fleas" cyclops, daphnia,[8] all of which are very undesirable in a water supply.

Chlorine in Fungus and "Slime" Control.—Fungi and filamentous slime-like growths such as Leptomitus and Sphaerotitus which occur in sewers and polluted streams are easily killed with chlorine and thereafter slough off and are swept away. In many paper mills biological growths appear in the chests and vats. These growths are known as "slime." Chlorination of the water supply or the "white water" returned to the process is proving very effective in controlling "slime" formation.[16] "Slime" is frequently responsible for an inferior product, or a material loss in production because of temporary shutdown of paper machines, and mill shutdowns for cleanup. Upwards of 40 mills already employ chlorine for "slime" control.

A development along a similar line is the use of chlorine as a preventive of "sliming up" of tubular steam condensers. Chlorine intermittently applied to the cooling water prevents slime deposits on the tube, thus maintaining a higher efficiency of heat transfer and vacuum in the condensers, and a lower operation cost as a result of fewer shutdowns for cleaning and fewer manhours of labor by the cleaning gang.

Chlorine in the Realm of Coagulants.—Ferrous sulphate ($FeSO_2:7H_2O$), known as "copperas," has been employed in conjunction with lime as a coagulant for water, sewage and industrial wastes for many years. Mohlman and Palmer[18] suggested and tried the chlorination of a solution of copperas to produce a ferric compound which proved an efficient and economical coagulant for dewatering sludge from the activated sludge process.

Copperas, unless used in conjunction with lime, possesses no value as a coagulant, whereas chlorinated copperas requires no lime, unless the natural alkalinity of the water is extremely low. With organically colored waters, chlorinated copperas is particularly effective. On water containing clay suspension and little or no organic color, it has likewise proven effective.

During 1928 a successful full plant scale demonstration with "chlorinated copperas" has been given. The recent paper[17] by L. L. Hedgepeth, Superintendent of Filtration at Elizabeth City, N. C., gives the detailed account of the process which continues in use at this city with excellent results. One pound of liquid chlorine will oxidize between 7.8 and 8.2 pounds of commercial copperas ($FeSO_4:7H_2O$). The use of chlorine in ton container shipments materially reduces the cost of chlorinated copperas and for this reason it may be classified among the lower cost coagulants. The two methods of preparation are given in the papers of Mohlman and Palmer[18] and Hedgepeth[17].

The Oyster and Clam Industry.—Recent studies[22] indicate that oysters contaminated by B. typhosus when in their natural habitat remain infectious for a period of three weeks following contamination. Purification of oysters with chlorine water was first experimentally applied in 1914 by W. F. Wells[23]. The process was more fully developed by Wells and others[24,25] during 1920-1922, but it did not attract much attention, until the typhoid epidemics of 1924 in New York, Chicago, and Baltimore were traced to contaminated oysters. Since 1924, chlorination of oysters has received increased attention and in 1925 and 1926 investigations by the U. S. Public Health Service[27] confirmed the claims made for the process. No harmful effect on taste or appearance of live unshucked oysters was noted. However, it is not recommended that dependence be placed upon chlorination to make oysters from dangerous polluted areas safe. On the other hand, oysters from areas about which there may be some question as to positive safety, at all times may be rendered safe by chlorination.

Chlorination of oysters has been likened to pasteurization of milk which enhances the safety of the milk, but does not supplant the care used in the milk plant to keep the milk up to standards of cleanliness. Chlorination of oysters constitutes a highly valuable "factor of safety" by the industry and to the consuming public.

Early in 1925, at West Sayville, L. I., one of the largest oyster packing plants on the Atlantic seaboard adopted the chlorination process and continues to use it. Within the past year or two a number of packers have equipped their plants for chlorination of oysters. The process is described by W. F. Wells[28].

PART II

Advances and Development in Sewage Chlorination

Although sewage chlorination was in reality the forerunner of water chlorination, its growth has lagged until within recent years. The advent of the fifteen and thirty ton liquid chlorine tank cars and more especially the multiple unit car of 15 demountable containers, each of one ton chlorine capacity, has served to awaken renewed interest in sewage chlorination. Chlorine is as a result available at a

The One Ton Liquid Chlorine Container. Note the Duplicate Valve Arrangement and Also That Chlorine Gas May Be Drawn While Container Is Lying Prone or Standing Upright, as Preferred. Container Dimensions: Outside Diameter, 30 In.; Length, 80 In.; Weight, empty, 1300 Lbs.

delivered price approximately one-half that previously paid and thereby the cost of sewage chlorination becomes much more attractive than formerly.

Several new uses for chlorine in sewage treatment have been developed and now chlorination may be considered not alone as a health measure, but also as an adjunct to the several existing methods of sewage disposal. It seems to fill the need often apparent for an inexpensive and simplified process capable of improving objectionable conditions or those which interfere with efficient functioning of sewage plants and sewerage systems.

Disinfection.—In order that efficient disinfection may be continuously and consistently secured, it is essential that sufficient chlorine be applied to insure the presence of 0.2 parts per million or more residual chlorine after a 10 to 15 minute period of contact.[2,3] The total amount of

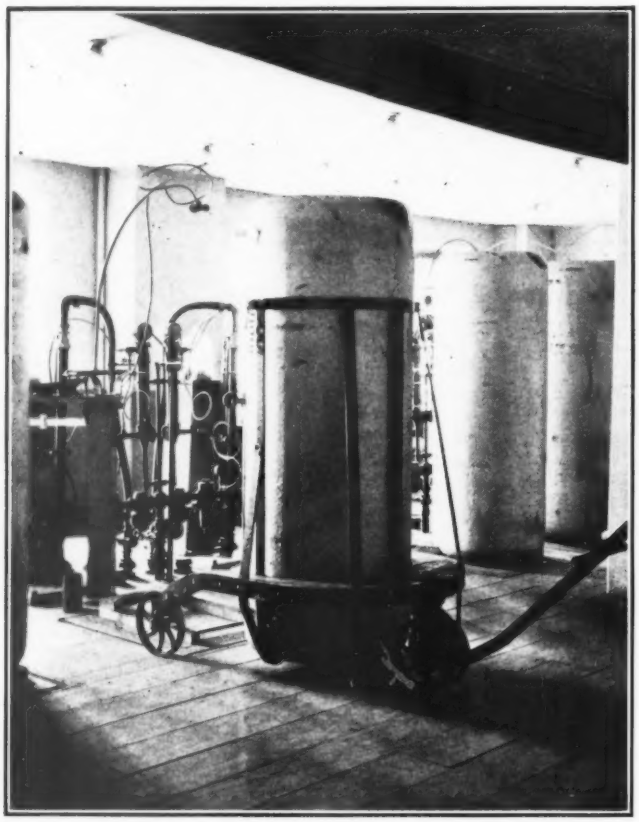
Unloading One Ton Liquid Chlorine Containers (15 to a Car). These Are Transported Singly in One Ton Trucks to the Chlorination Plant

chlorine required is a function of the "chlorine demand" of the sewage or effluent which in turn varies with the quality of the sewage, i. e., whether or not the sewage is concentrated, fresh, stale or actually septic. The weaker and the fresher the sewage the lower will be the chlorine demand. It has been demonstrated that one is warranted in making only rough estimates as to the actual quantity of chlorine required under given conditions. It is paramount that chlorine equipment of adequate capacity to cope with the highest expected demands of the sewage be provided. Thereafter the best results with least expense may be secured by regulation of the chlorine dosage to produce the desired residual chlorine in the sewage.

In the great majority of instances the following minimum and maximum requirements will cover the situation.

Nature of the Sewage	P.p.m. Cl
Crude sewage or settled sewage (fresh to stale)	5 to 15
Crude sewage or settled sewage (septic)	10 to 25
Sprinkling filter effluent (influent to final settling tank)	2 to 5
Activated sludge effluent	1 to 3.5

Prechlorination of the crude sewage possesses many points of advantage when tank treatment and chlorination constitute the only treatment given. Aside from requiring



One Ton Liquid Chlorine Containers Connected to Chlorinators. Alternate Arrangement Allows Containers to Be Rolled Onto Scale Platform and Gas Fed to Machines From the Prone Position

less chlorine on the average the settling chambers serve as contact chambers of long period detention and obviate the necessity and expense incurred in providing additional contact chambers beyond the settling tanks. The tanks serve admirably as "balance wheels" to smooth out fluctuations in the quality and quantity of the sewage flow, and a more uniform result is secured when chlorinating the influent sewage. The chlorine is controlled by testing for residual chlorine at or near the influent end of the settling chambers. Other advantages from prechlorination aside from economy and efficiency of disinfection are discussed later.

In case the treatment plant embraces secondary treatment such as trickling filters, chlorine for disinfection and other incidental advantages[4] should be applied at the influent end of the secondary settling tanks, i. e., to the filter effluent rather than to the final effluent. To apply it ahead of the filters would be wasteful practice in instances where disinfection is the chief end sought.

Prechlorination and Split Chlorination.—Attempts to employ the direct feed of chlorine gas to sewage through submerged diffusers have not met with success when the dosage applied exceeds 3 to 3.5 p.p.m. By far the most practical method is that of solution feed wherein the applied chlorine water is mixed with the sewage flow.

At smaller sewage plants it frequently happens that water under pressure is not available. Under such circumstances, the chlorinator may properly be located some distance up the trunk sewer at a point where the muncipal water supply may be available. If there is a crude sewage pump station available within reach of the water mains, the chlorinator should be located at this point. In such cases semi-automatic chlorinators which operate simultaneously with the sewage pumps may be advantageously employed.

If in addition it is considered advisable to chlorinate the effluent at the plant, the major chlorination may be accomplished as above and final effluent chlorination at the plant may be secured with direct feed equipment because of the limited additional chlorine required by the already partially chlorinated effluent. Thus it appears that split chlorination may prove more desirable than single prechlorination in some circumstances.

Disinfection of Fine Screen Sewage.—The investigations of Scott and Poole[3] are the first to produce knowledge as to the expected efficiency of chlorination in conjunction with fine (mechanical) screening of crude sewage. The degree of penetration of the suspended solids was carefully determined as was the value of various periods of contact and residual chlorine concentrations required for contact periods of 15 minutes or less. The data indicates that mechanical screening with chlorination may be depended upon to produce a safe effluent for disposal through ocean outfalls or into major water courses where the chance of nuisance production is remote.

Correction of Odor Nuisances.—Volatile gases are liberated from sewage by aeration in sewers, manholes, a drop over wiers, or more especially from sprinkling filter sprays. The chief offender in this respect is hydrogen sulphide and allied compounds which to most people possess a nauseating odor and serve to accentuate other odors which in themselves might not be objectionable. The presence of hydrogen sulphide gas in sewers is indicated by swelling of mortar joints, softening of concrete and also by blackening of brass, copper or silver. Blotting paper wetted with a saturated lead acetate solution will darken when left exposed in pump sumps or manholes where hydrogen sulphide is present. Any appreciable concentration is thus promptly indicated.

To suppress or arrest hydrogen sulphide production over a desired period of time the crude sewage may be fractionally sterilized to any required degree with chlorine applied at some selected point ahead of the disposal plant. Usually the chlorination should take place at or near the plant proper but there are occasions when chlorination a considerable distance up the trunk sewer is warranted. Such is the case when odors emanate from manholes or where masonry sewers are suffering destruction above the flow line as a result of hydrogen sulphide evolution and subsequent acid production.

Effect of Prechlorination on Plant Performance.—The natural question in the mind of the average reader is, "But what happens to the sludge digestion and the biological filters when the crude sewage is first chlorinated?"

At Portsmouth, Ohio, where prechlorination has been in continuous use for three years, no deleterious effects on sewage solids digestion have been observed. As a matter of fact, the Imhoff tank performance appears to have been improved and scum in the vents is conspicuous by its scarcity.

Investigation by Dr. Willem Rudolfs and W. J. O'Connell of the New Jersey Sewage Experiment Station in connection with prechlorination at the Plainfield, N. J., plant, disclose no harmful effects on subsequent digestion of the solids separating from sewage containing residual chlorine.

Cohn[15] at Schnectady reports that sludge from tanks receiving prechlorinated sewage appeared to be superior to that from parallel tanks receiving unchlorinated sewage. Fair and Carlson[16] at Harvard University conducted two distinct series of tests in which solids from the same sewage—one portion having been heavily chlorinated and the

other not chlorinated—were compared for rates and thoroughness of digestion. The rate of digestion as indicated by methane gas (CH_4) production indicated a more rapid digestion of the solids from the chlorinated sewages than was observed for the unchlorinated. At Bath, England, prechlorination has not proven deleterious to sludge digestion and at Baltimore, Md., additional investigations along this line on a small plant scale are now under way.

At Lufkin[17] and Breckenridge, Tex.[18] foaming of Imhoff tanks was alleviated following introduction of prechlorination. F. C. Dugan of the Kentucky State Board of Health reports a similar experience at a small plant. On the other hand, there have been two instances wherein prechlorination was not effective in controlling foaming of tanks.

At Schenectady, N. Y.[15] and Canton, Ohio, prechlorination produced flocculation of some of the nonsettleable matter in the flow chambers.

At Canton, Ohio, very soon after beginning prechlorination, the sprinkling filter effluent improved in quality and biochemical oxygen demand value. The filters unloaded their organic accumulations and the surface algae growths were killed and washed out.

At Singapore, Straights Settlement,[19] chlorination was employed to clean up the badly ponded trickling filters. Following this the filters improved in efficiency and the improvement in quality of effluent was marked. At Schenectady[15] the nitrification through the filters increased following drastic chlorination to free the stone of heavy film growths. At Bath, England, the oxidation by the filters has apparently been somewhat greater as a result of prechlorination of the crude sewage to retard septic action in a 5-mile main.

At Lackawanna, N. Y.,[32] a serious case of filter ponding as a result of algae and light solids discharging from the Imhoff tanks was reducing the plant efficiency. Clorination of the tank effluent to the filters relieved this condition. This was a representative case of pronounced filter ponding and the value of chlorine as a remedy for such difficulties was demonstrated beyond all expectations.

Effect of Chlorine on Putrescible Matters in Sewage.—The putrescible matters in sewage effluents are measured by determining the demand exerted by the sewage for dissolved oxygen. This oxygen absorption is spoken of as the biochemical oxygen demand. This demand varies with the organic content, the nature of the organic matter present and the period of contact of the sewage with the cleaner water containing the dissolved oxygen. Killing of fish, odor nuisance, and the foul appearance of the streams receiving sewage are all matters which may be avoided by reduction of the oxygen demand of the sewage to a point at which it will not deplete the oxygen in the receiving stream.

Biological beds such as sprinkling filters and oxidation processes such as the activated sludge process effect marked reductions in the oxygen demand of sewage. Simple settling out of the solids from crude sewage results in reductions of from 30 to 40 per cent of the oxygen requirement of the crude sewage.

Chlorine is a powerful oxidizing agent but aside from this property there appears to be an additional effect secured from chlorination which reduces the oxygen demand of sewage and can only be explained by assuming that some of the organic matter in true solution or in the colloidal state is chemically changed by chlorination with chlorine. In so changing the composition of the food supply of the bacteria or other biological forms always present in the receiving stream there is less oxygen demand exerted by the chlorinated sewage. This because some of the putrescible matter has been rendered non-putrescible or less putrescible even in the presence of great numbers of bacteria.

Chlorination does not reduce the oxygen demand of settled sewages to anything like that secured by efficient sprinkling filters but this could hardly be expected. As a rule settling tanks followed by sprinkling filters will reduce the five-day oxygen demand of the crude sewage by roughly 80 to 85 per cent. Chlorination will usually reduce the demand of a settled effluent somewhere between 25 and 35 per cent and thus an overall reduction of the five-day demand for the tanks plus chlorination somewhere between 55 and 65 per cent is secured provided the settling tanks are fairly efficient and bring about a reduction of approximately 40 per cent in the demand without chlorination.

Under certain conditions when more than tank treatment is indicated, but where the extent of oxidation by biological processes does not seem requisite, then tank treatment in conjunction with chlorination may serve to fill the existing gap now found between the purification available from settling tanks alone and that high degree of oxidation afforded by the expensive biological processes. In certain instances tank treatment may suffice for the periods of the year when stream flow is adequate whereas with less water in the streams chlorination as an adjunct to tank treatment may prove very much worth while.

Notable reductions in the organic nitrogen content of sewage effluents at Bedford and Mt. Kisco, New York, plants have resulted from chlorination.[20]

The first work done in respect to the effect of chlorine to reduce biochemical oxygen demands of settled sewage was Dallas, Texas, by cooperative arrangement between the Texas State Health Department, the City of Dallas, and The Chlorine Institute, Inc., early in 1926. The unpublished results showed positive reductions which varied in extent with the strength of the sewage. Since this work there have been several investigations, made along the same line, by Morton at Harvard University,[21] Cohn at Schenectady,[15] Tiedeman at Huntington, L. I.,[2] Ellms at Cleveland, Ohio, McGuire at Columbus, Ohio,[22] Baity at Chapel Hill, N. C.,[23] Reinke at Tulare, Calif., O'Connell at New Brunswick, N. J., Carpenter at New York (Jamaica plant), and Mohlman and Hurwitz at Chicago.[33] Much of this work has not yet been published, but the results are interesting in that they confirm the earlier work.

At Cleveland, Ohio, results are available for the years 1927 and 1928 which show reductions as follows:

Cleveland, Ohio

Year	Sewage Chlorinated	P.p.m. Avg. Chlorine	5-Day BOD P.p.m.	Reduction Per Cent
1927	Screened	7.27*	23	17.5
1927	Settled	9.72*	26	26.0
1928	Screened	8.55*	20	14.5
1928	Settled	9.85*	25	23.0

*Chlorine dosage not sufficient to produce residual chlorine in samples examined.

Effect of Chlorine on Slime Like Growths in Sewers and Streams.—The application of chlorine or hypochlorite of lime (bleach) has resulted in ridding sewers of the slime like growths that sometimes produce trouble. This effect was pronounced at Canton, Ohio, Plainfield, N. J., and Porterville, Calif.

Small streams containing heavy filamentous growths have been cleared up by chlorine application to the sewage effluent.

At Leipsig, Germany, chlorination of settled sewage had a marked effect in reducing heavy biological growths in the river below the sewage plant and thus saved the city from impending legal action by riparian owners below.[14]

Sludge Conditioning and Chemical Precipitation with Chlorinated Copperas and Ferric Chloride.—Seeking a cheap source of ferric iron salts for conditioning activated sludge in vacuum filtration Mohlman and Palmer at Chicago (1926) found that ferrous sulphate, commonly known as "copperas," after oxidation with liquid chlorine served as a very satisfactory and inexpensive coagulant.[25] Shortly following the Chicago work Fugate and Stanley applied chlorinated copperas experimentally for sludge conditioning which work has resulted in a large scale installation at the Houston, Texas, plant.[26]

Milwaukee, Wisc., was the first (early 1927) to employ chlorinated copperas for dewatering activated sludge on a large scale.[27,28] In this development H. M. Heisig, Chief Chemist, and his staff at the Milwaukee plant, together with D. P. Smith of the Pennsylvania Salt Mfg. Co. are due credit for solving the several difficulties involved in such large scale production of the chlorinated copperas. Ferric chloride seems to be somewhat superior to chlorinated copperas in the Milwaukee plant and will be employed in the future, unless the overall cost of dewatering and drying favors return to chlorinated copperas. Sulphuric acid is at all times employed in the conditioning process in conjunction with the coagulants. Daily tests are conducted in order to secure the most economical combination of acid and ferric salts. At times aluminum salts may be employed also, if the price favors their use. In summer little if any conditioning agent other than the acid is employed. Research at Milwaukee has been productive in materially lowering the cost of sludge dewatering and drying during the

past year. The most recent data available to the author indicates a chemical cost of something under $3.00 for each ton of fertilizer produced.

Houston, Texas, employs chlorinated copperas and Charlotte, N. C., employs ferric chloride. Pasadena, Calif., and Indianapolis, Ind., are experimenting with ferric chloride also.

Chlorinated copperas is prepared at Milwaukee, Houston, and Chicago, by the addition of chlorine gas to a concentrated solution of copperas ($FeSO_4:7H_2O$) as described by Mohlman and Palmer.[25] At Elizabeth City, N. C., a dry feeder supplies the desired flow of copperas to produce a solution into which a continuous flow of chlorine water from a Wallace & Tiernan chlorinator is introducted en route to the point of application. The reaction involved is simple and extremely rapid—

$$\overset{++=}{FeSO_4}:7H_2O + \overset{0}{Cl} = \overset{+++}{Fe} + \overset{---}{SO_4} + \overset{-}{Cl} + 7H_2O$$

In practice one pound of chlorine serves to oxidize the iron in 7.8 to 8.2 pounds of copperas, depending upon the ferrous iron content of the copperas. The use of chlorine in tank car or multiple unit ton container shipments[1] renders the cost of producing chlorinated copperas much more attractive than is the case when chlorine is purchased in 150 pound cylinders.

Ferric chloride is shipped to Milwaukee from Niagara Falls in rubber lined tank cars. The solution contains roughly 50 per cent $FeCl_3$ and is stored at Milwaukee in rubber lined tanks built especially for the purpose. Smaller plants purchase the crystal ferric chloride which is not only more expensive but more difficult to handle. Anhydrous ferric chloride is obtainable and probably has a future in small installations if not at large plants.

As an agent for chemical precipitation "alumino-ferric" compounds have been successfully employed for years in England. In America copperas in combination with lime, or aluminum sulphate in combinations with acid or lime have been favored.

In connection with chemical precipitation of alkaline wastes including laundry waste water ferric chloride or chlorinated copperas in conjunction with acid seems to have considerable merit. Nothing to date has been published concerning this but experimental applications now under way seem very promising. Ferric chloride and chlorinated copperas seem to rank about equal in merit and therefore any preference is governed almost entirely by economic considerations. The major advantage from use of a ferric salt is the lack of necessity for lime application which usually means less sludge to handle subsequently.

We have reports of successful application of ferric chloride in cannery waste precipitation and work is to be undertaken in connection with its application in the treatment of creamery wastes.

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[31]L. H. Enslow. The Paper Mill, Dec. 8, 1928 (p. 20).
[32]F. K. Wing and Roger Williams. Eng. News Record, Apr. 18, 1929 (p. 621).
[33]F. W. Mohlman. Proc. 11th Texas Water Works Short School, 1929.
[34]E. A. Reinke. Calif. Sewage Wks. Jour., Vol. 1 No. 1, 1928 (p. 128).

THE LaMOTTE CHEMICAL PRODUCTS COMPANY

McCormick Building, Baltimore, Maryland, U. S. A.

Materials and Equipment for Simple, Rapid pH Control

Products: MATERIALS AND EQUIPMENT FOR pH CONTROL BY THE COLORIMETRIC METHOD. STANDARDS, SOLUTIONS AND EQUIPMENT FOR THE ANALYSIS OF WATER, SEWAGE AND INDUSTRIAL WASTES.

LaMotte Roulette Comparator: The ideal equipment for simple, rapid pH control. Covers range of three indicators and gives maximum of simplicity, accuracy and speed in making pH measurements. Is readily portable and can be used at night as well as during the day. The revolving drum holds 3 complete sets of LaMotte Permanent Color Standards and 27 ampoules of distilled water which are always in place, thus eliminating danger of breakage by handling. There is also a special lighting arrangement so that the observer always makes his readings under standard daylight conditions. The outfit comes complete with 50 c.c. of each of the corresponding indicator solutions, 3 pipettes, 18 graduated test tubes and full directions for use. Any plant foreman can easily be taught to carry out routine determinations with this simple outfit, making the benefits of pH control as readily available in the plant as in the laboratory. Price, $60.00, f. o. b., Baltimore.

LaMotte Roulette Comparator

LaMotte Block Comparator: A smaller and more compact outfit than the Roulette Comparator, which is widely used in smaller plants and for "trouble shooting." Covers range of one indicator. Range can be extended by additional sets. A special Dalite Comparator Lamp can be supplied with this set so that determinations can be made at night or in dark places. Price, $12.50, f. o. b., Baltimore. Special Dalite Comparator Lamp, $7.50, f. o. b., Baltimore.

LaMotte-Enslow Chlorine Comparator: For determining free or residual chlorine in drinking and swimming pool water, sewage, industrial wastes, etc. Eliminates the effects of color and turbidity, and also the error due to the presence of manganese, iron, nitrites or any other interfering substance in the material being tested. Price, $12.50, f. o. b., Baltimore.

Water Analysis: A complete line of permanent standards and standard solutions for water analysis, as well as special apparatus for use in this work. These standards and solutions are made with the greatest care and are standardized in strict accordance with the specifications given in "Standard Methods of Water Analysis." They bear our unqualified guarantee of uniform accuracy.

LaMotte Sludge Testing Set.: This improved apparatus is especially designed for the rapid testing and accurate control of the pH of sewage sludges. The dilution method not only eliminates the necessity for filtering or centrifuging, but, in conjunction with the use of a special comparator and special color standards, overcomes difficulties due to color and turbidity. Price, $30.00, f. o. b., Baltimore.

Write for a complimentary copy of our combination textbook and catalog, **"The A B C of Hydrogen Ion Control,"** which contains valuable information on all these methods, as well as complete descriptions and prices of materials and equipment.

WALLACE & TIERNAN COMPANY, INC.

Newark, New Jersey

Manufacturers of Chlorine Control Apparatus

SALES OFFICES AND SERVICE HEADQUARTERS

New York, Los Angeles, Chattanooga, Chicago, Seattle, Knoxville, St. Louis, Charlotte, San Francisco, Buffalo, Oklahoma City, Minneapolis, Ogden, Indianapolis, Pittsburgh, Detroit, Philadelphia, Dallas, Boston, Spokane, Kansas City, Jacksonville

Wallace & Tiernan, Ltd., Toronto, Canada

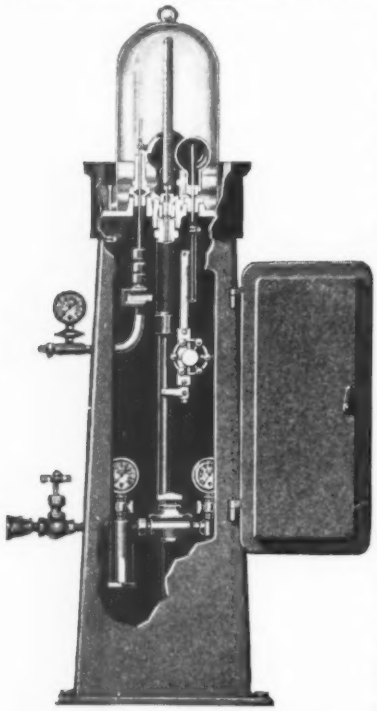
Wallace & Tiernan, Ltd., London, England

Chlorination: The rapid growth of chlorination practice and the corresponding rapid reduction in typhoid fever death rates parallel so closely that graphs are complete proof of the value of 100% sterilization of water supplies. It can be truly said that every watershed in the country is subject to pollution.—Pollution has spread with the rise of cities and the travel of automobiles. The ground waters are being contaminated in myriad ways,—*"The only safe water is a sterilized water."*

Liquid chlorine is the cheapest most efficient agent for the sterilization of drinking water, for the disinfection of sewage and for the sanitation of swimming pools. Applied in minute amounts it will destroy any disease organisms of water. Its use will completely prevent the transmission of water borne typhoid fever, dysentery and cholera.

Chlorination sterilizes 100,000 gallons of water for an average of three cents. Liquid chlorine is safeguarding the water supplies of over 5,000 municipalities using a total of six billion gallons of water each day. No flight of the imagination can suggest a more valuable work than the campaign of sanitarians and public health engineers "To Guard the Public Health" by demands for careful sterilization of all public water supplies.

Ordinary standards of sanitation—the sense of civic responsibility and the staggering cost of an epidemic—are there any better reasons to urge every community to enforce such simple protection? The chlorinator is final protection. The chlorinator works when all other treatment fails.



W & T MSV Vacuum Type Solution Feed Chlorinator
"The Peer of All Chlorinators"

Vacuum Type Chlorinator: Simplicity of operation is the outstanding advantage of the W. & T Vacuum Type Solution Feed Chlorinator. Small fragile parts are eliminated. The apparatus, is designed so that no moving parts can be out of adjustment. The entire apparatus is hydraulic in principle and no parts are moving when the chlorinator is in operation. The fundamental advantages of all W & T Chlorinators are retained with the same high percentage accuracy of chlorine flow.

The MSP Type Chlorinator is designed to meet the varied requirements of the average small water works. The operation of the equipment is evident in the detail drawing. The solution feed assures better diffusion of the sterilizing solution than the direct feed. Either pressure application or gravity feed of the chlorine solution is possible it being only necessary that a water supply under sufficient pressure be available for operation.

Duplicate MSP Chlorinators are Safeguarding the Water Supply of Hundreds of Small Cities Throughout the World.

The primary aim has been to produce a machine which will not only accurately control the necessarily small amount of chlorine but will also be of such simple construction as to be readily understood by the practical water works man. The progress of chlorination is the history of Wallace and Tiernan. For, the prerequisite of successful chlorination is a sturdy, dependable, accurate chlorinator.

Sterlization is accomplished not with tons of chlorine for every every million gallons but it is the work 0.3 to 1.2 parts per million. The accuracy of treatment is comparable to the most exact chemical analyses. One part per million is equivalent to eight and three tenths pounds of chlorine in one million gallons of water.—Chlorination is a real problem of accuracy.—But dependability is even more important than accuracy. Chlorination means correct, reliable operation every minute of every day. The Wallace & Tiernan Vacuum or Pedestal Type Chlorinator bears little resemblance to the pioneer of 10 years ago. The radical changes were not for accuracy but solely to perfect equipment independent of mechanical vital moving parts. The production of hydraulically operated apparatus gained the complete confidence of the engineering and water works profession—a confidence so firm that chlorination and sterilization are synonymous.

Briefly, a Wallace & Tiernan chlorinator is the product of constant effort—ingenious design and practical experiment, so, it is the scientific apparatus, complete in every detail, the standard of perfection—exact, yet simple to operate.

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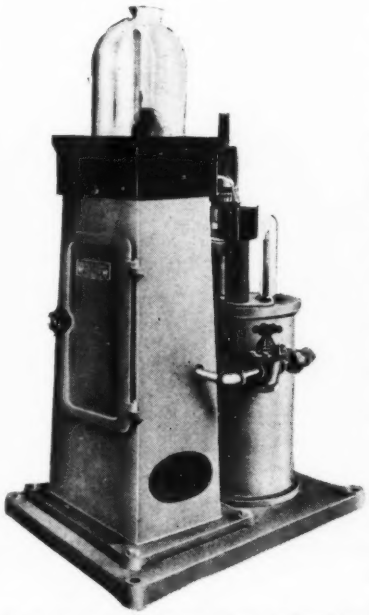


W & T ASV Vacuum Type Automatic Solution Feed Chlorinator

Were the field of usefulness of chlorine limited to sterilization it would be "good work well done." But the practical research of investigators during the last few years has extended the use to include algae control—taste control—improved coagulation (with chlorinated copperas and prechlorination) and to use in sewage treatment for odor control and reduction of the biochemical oxygen demand.

Chlorination for Algae Control: L. B. Mangun, superintendent of the Kansas City Filtration Plant, has had marked success controlling algae in the distribution reservoirs with chlorination. Chlorine is preferable to copper sulfate since the dosage can be accurately controlled and there is no fear of controversy in case some of the chlorine remains in the treated water. Algae control is successful in such scattered localities as New York and Texas, Virginia and New Jersey.

Chlorination of raw water at filter plants further than increasing bacterial safety and destroying algae permits longer filter runs and is reported to allow a reduction in dosage of coagulant—while, the consequent prevention of "slime" on the sand grains means less trouble from "cracking" and mud balls,—Mention of coagulants should include chlorinated copperas (ferrous sulfate) with its wide coagulating pH range and particular advantages for color removal.

Superchlorination and dechorination, first practiced on a large scale at Toronto, promise solution of many water tastes problems. An excess dosage of chlorine will destroy organic tastes and the residual chlorine is neutralized by correct dosage of sulfur dioxide. (Sulfur dioxide is measured and fed with W & T equipment.)

Chlorination of Sewage and Wastes: As to sewage—its odors are principally hydrogen sulfide—chlorination will not only destroy H_2S but will retard the bacterial action producing it. Sewage treatment is not a process of sterilization unless chlorination is a part, but chlorination is not only sterilization it is definitely a treatment process which reduces the biochemical oxygen demand by 25-30%.

The industrial uses of chlorine requires careful control. Chlorine solutions of accurate concentration are invaluable in laundries. The utensils of dairies, canneries and bottling works are most easily and perfectly sterilized, with carefully made chlorine solutions. Even oysters are chlorinated as an additional precaution to protect the consuming public. "Slime" in paper mill vats—the cause of weakness and flaws in stock—is destroyed by correct chlorination. The "slime" growths in steam condensers are prevented by chlorination—the control of slime means a saving in steam and a saving of cleaning labor. The textile mills bleach with chlorine. Highly colored dye wastes may be decolorized by chlorination.

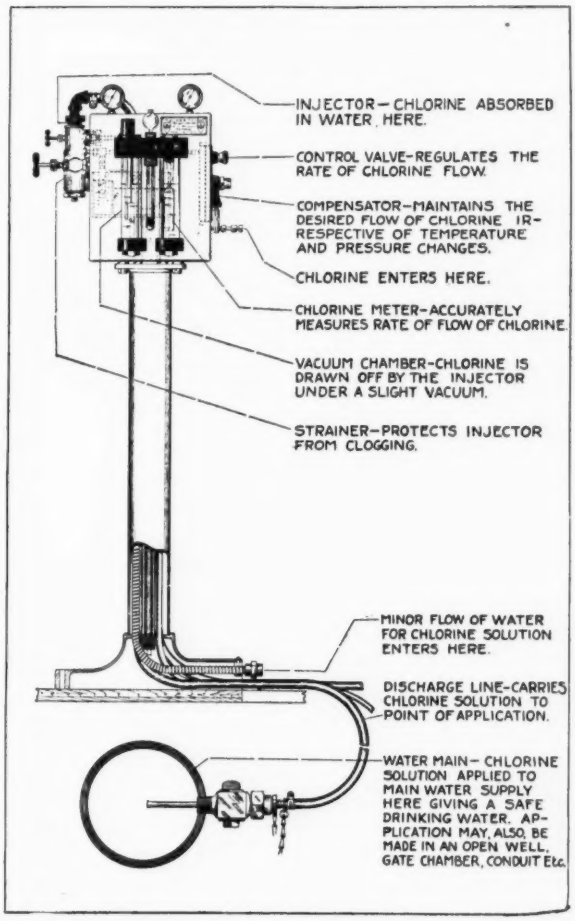
At best the major uses have only been mentioned but progress, improvement and new ideas indicate increasing possibilities of unrecognized value.

Automatic Chlorination: The automatic application of liquid chlorine for water sterilization and sewage disinfection is highly important wherever there are rapid changes in the rates of flow or under variations between maximum and minimum flows.

Automatic chlorination is not news, but the new success of the W & T Automatic Chlorination is news. The first ASV chlorinator was installed in 1927. Today Seattle, Los Angeles, Chicago, New Haven, Portland, Maine, Birmingham, Bridgeport, Baltimore, Rotterdam, Holland, depend upon the automatic chlorinator for "safe water." The equipment is a development of the W & T Vacuum type chlorinator. It has the same accuracy and the same hydraulically operated chlorine control, but, in addition, the automatic control of dosage is entirely hydraulic. In fact, there is even less lag in the change of dosage of chlorine than in a Venturi recorder.

The differential head obtained by the flow of water through a venturi tube, orifice plate, pilot rod or over a weir, is transmitted to a differential reducing device which varies the vacuum head on the chlorine meter in the vacuum chamber of the chlorinator precisely in proportion to the flow of water to which the chlorine is being applied. An accuracy test of one of these units after several weeks operation indicated that the average variation of chlorine flow from the theoretically correct chlorine flow was only 0.38 of 1% the maximum error being 3% and the minimum error zero.

The Automatic Vacuum Chlorinator is the solution of sterilization problems where there are rapid changes in the rates of flow or where there are wide variations between maximum and minimum flows.


INJECTOR—CHLORINE ABSORBED IN WATER HERE.
CONTROL VALVE-REGULATES THE RATE OF CHLORINE FLOW.
COMPENSATOR-MAINTAINS THE DESIRED FLOW OF CHLORINE IRRESPECTIVE OF TEMPERATURE AND PRESSURE CHANGES.
CHLORINE ENTERS HERE.
CHLORINE METER-ACCURATELY MEASURES RATE OF FLOW OF CHLORINE.
VACUUM CHAMBER-CHLORINE IS DRAWN OFF BY THE INJECTOR UNDER A SLIGHT VACUUM.
STRAINER-PROTECTS INJECTOR FROM CLOGGING.
MINOR FLOW OF WATER FOR CHLORINE SOLUTION ENTERS HERE.
DISCHARGE LINE-CARRIES CHLORINE SOLUTION TO POINT OF APPLICATION.
WATER MAIN—CHLORINE SOLUTION APPLIED TO MAIN WATER SUPPLY HERE GIVING A SAFE DRINKING WATER. APPLICATION MAY ALSO BE MADE IN AN OPEN WELL, GATE CHAMBER, CONDUIT Etc.

Manual Control Chlorinator Solution Feed Type MSP and MSPM.

The installation of W & T chlorine control apparatus only requires minor construction and piping easily arranged by the water department mechanic.

It is advisable to house the chlorinator where the room temperature is evenly maintained above 50° F. The installation of W & T equipment is supervised by W & T engineers.

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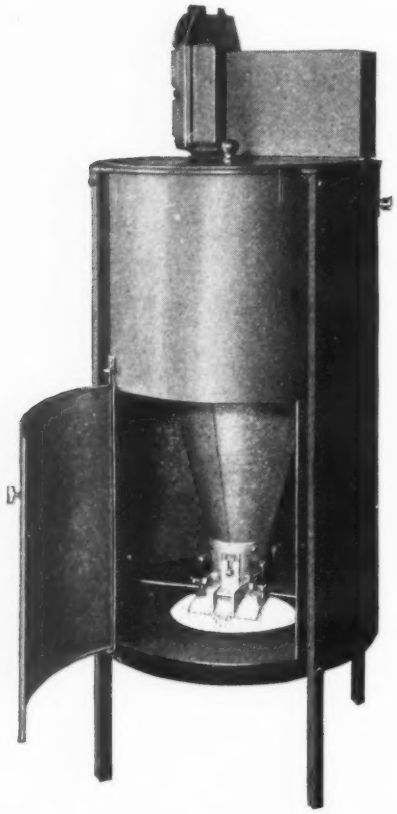
W & T Dry Chemical Feeders



W & T Dry Chemical Feeder Type "O" Rugged—Compact—Reliable.

Type "O" Feeder: This new dry chemical feeder is essentially a low capacity feeder, having a feed range from 1/10 pound to 80 pounds per hour, depending on the chemical fed. It may be used with either course granular crystalline chemicals such as alum or with the finer powdered chemicals as lime.

The entire machine with the exception of motor and gear case which are separately encased, is enclosed by a sheet metal housing with tight fitting doors. A cover is provided for the hopper.

The steep sloping hopper is agitated by an unique system of levers which flex so as to keep every particle of chemical moving at all times. This gives the chemical an even consistency and a uniform rate of feed into the throat. Thus arching and its troublesome operating difficulties are eliminated.

The 1/6 H. P. constant speed motor is directly connected. There are no pulleys or belts to worry about. It may be operated from an ordinary light socket. Power consumption is remarkably low. It takes less that 5 k. w. per day

The adjustment by a conveniently located hand wheel geared to a scale lever is an outstanding feature of the feeder. A 200 division scale permits great ease and accuracy of adjustment. The feeder is adaptable for overhead feed if desired. Feed to the point of application may be direct through a 12″ sheet metal pipe or as a solution using a special W & T Solution pot. The finish is neat and durable. All exposed parts are either painted with W & T Gray Duco finish or are cadmium plated.

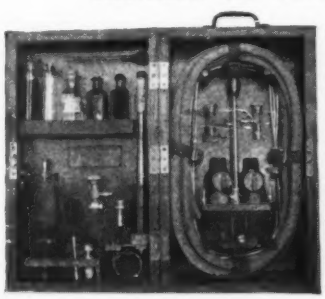
W & T Type B Chemical Feeder is manufactured in two capacities. One is known as the low speed feeder and the other as the high speed feeder. Depending on the pulley size and the chemical used the low speed feeder has a minimum rate of feed of 0.5 pound per hour and a maximum of 150 pounds per hour. The high speed feeder has a similar range of 7.5 minimum and 1,080 maximum, in pounds per hour.

W & T Type B Dry Chemical Feeder.

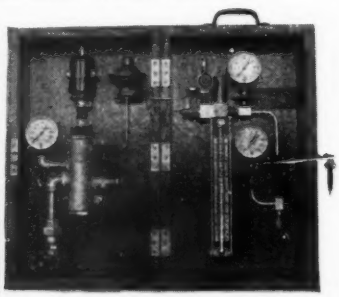
In the W & T Type B Dry Feeder the pulverized or granular chemical is placed in the hopper. The chemical flows on to a revolving feed table through the feed spout. This table together with suitable agitator mechanism is belt driven from an electric motor, water motor or line shaft. A stationary scraper removes the chemical from the revolving feed table diverting it to the receiving hopper from which it may be conducted by gravity to the point of application as a dry chemical. If desired the chemical may be mixed with water in the receiving hopper and the solution fed through a water operated injector to the point of application.

Chlorinator for Sterilization Water Mains

Every new or repaired water main should be sterilized before being put into service. Chlorine is the most efficient and economical chemical to use. Periodic chlorination of water mains will positively prevent objectionable after-growths in the distribution system.



Cabinet with Accessories and Residual Chlorine Testing Equipment

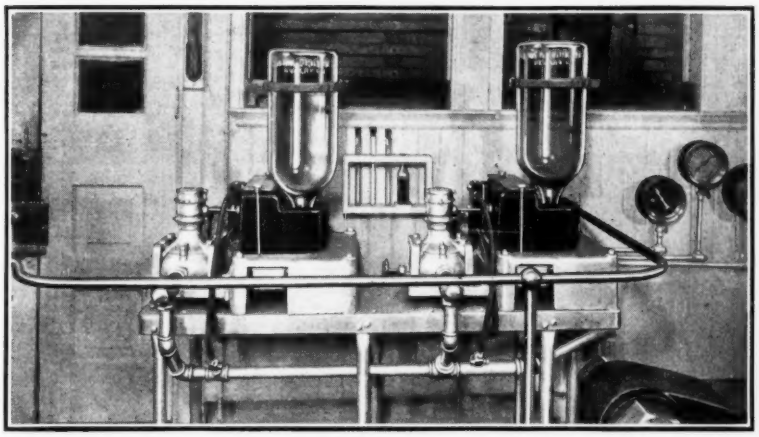


Cabinet with Chlorinators for Direct or Solution Feed.

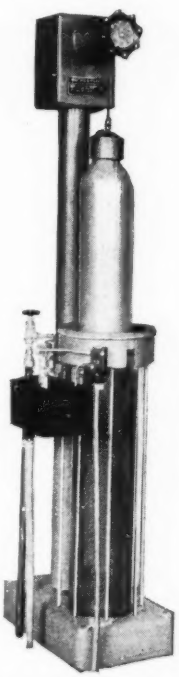
The new W & T Main Sterilizer provides for either direct or solution feed chlorination to the main. The apparatus is supplied with complete equipment for field chlorination and for making the necessary Ortho Tolidin test for residual chlorine. Every water works should own one of these sterilizers.

Continued on Next Page

The W & T Chlorometer is designed for sterilization of small water supplies. It is particularly adapted to the sterilization of supplies operated by automatic pumping systems. Hotels, private estates, country homes and boats on the Great Lakes use the W & T Chlorometer to insure the absolute safety of their domestic water supplies. Sterilizing solution will be introduced only when water is passing through the meter and at a rate proportional to the flow. While intended for small water supplies the Chlorometer has a wide range of usefulness for the proportional feed of many chemical solutions. Accurate, rugged, simple, fool-proof, it can be made absolutely automatic in operation, requiring no attention other than replenishing the three gallon bottle of sterilizing solution.



"Two W & T Chloro-Meters Installed to Sterilize the Drinking Water Supplied to the Steamship 'Western States,' Detroit and Cleveland Navigation Company."



"The W & T Chloro-Clock."

The W & T Chloro-Clock is the simplest accurate control device used in water sterilization. It is the ideal apparatus for chlorination of small swimming pools and constant flow water supplies. The control of treatment is obtained from a clock-work mechanism which regulates the rate of travel of a displacement cylinder. Adjustments in the rate of displacement and feed of sterilizing solutions are made by a pendulum control lever.

As with the Chlorometer, the Chloro-Clock may be fitted to regulate dosages of any chemical solution either required by industrial processes or as used in water works treatment. The Chloro-Clock is particularly recommended where the use of liquid chlorine is considered inadvisable as it is reliable, safe equipment requiring a minimum of attention.

The W & T Chloroscale gives a chart of the total amount of chlorine fed during a given period of time and a graph of the rate of chlorine flow from the cylinders.

A special clock mechanism revolves the chart while an accurately adjusted escapement mechanism automatically balances the scale beam, moving the pen across the face of the chart at a rate proportional to the rate of chlorine flow.

The W & T Chloroscale is furnished in response to a demand from water works superintendents and public health engineers for an automatic record of chlorinator operation.

"The W & T Chloro-Scale."

Wallace & Tiernan is an organization of highly trained technical men familiar with the fields of sanitation, bacteriology, chemistry and engineering, and is a staff of experts in the specialty of chlorination. The community worried with sanitary problems profits by advice of a Wallace & Tiernan representative,—he is a consultant on the applications of chlorine.

Who are Wallace & Tiernan? Wallace & Tiernan is an organization of highly trained technical men familiar with the fields of sanitation, bacteriology, chemistry and engineering, and is a staff of experts in the specialty of chlorination. The community worried with sanitary problems profits by advice of a Wallace & Tiernan representative,—he is a consultant on the applications of chlorine.

Every proposal is considered as an individual engineering problem and every installation is recognized as a responsibility for human life. The selection of correct types of equipment with proper capacities depends on detail differences in water systems and the variable character of waters. The selection can only be based on technical knowledge and on judgment of experience.

There are more than 10,000 installations of W & T equipment throughout the world for the sterilization of water, for the disinfection of sewage, for swimming pool sanitation, for deodorization and for the many purposes in industry or sanitation. The services of our Engineering and Research Departments are available for the solution of new problems.

Service is the business of Wallace & Tiernan so feel free to call for information on chlorination, sanitation, water works, or industrial operations. When a W & T Chlorinator is ordered you purchase continued cooperation and service from a nationwide field staff. The installation of the chlorinator is only the start of W & T's work.—From then on you will appreciate the motto "SERVICE."

Terms Used in Sewerage and Sewage Disposal Practice

The following was taken from *Municipal News and Water Works:*

The formulation of definitions of terms used in sewerage work was initiated in 1915 by the American Public Health Association. The work was continued by the committees of the Association until 1924. In May of that year the Sanitary Engineering Division of the American Society of Civil Engineers appointed a committee on definitions. Joint action between the two societies followed and an Oct. 22, 1924, at a joint meeting of the Sanitary Engineering Division of the American Society of Civil Engineers and the Sanitary Engineering Section of the American Public Health Association, a tentative report based on the work of the two committees was presented. The work was then continued and on Oct. 13, 1927, the joint report of the two committees was adopted by the Sanitary Engineering Division of American Society of Civil Engineers. The American Public Health Association adopted this report on Oct. 20, 1927, and on July 16, 1928, the report was also adopted by the Board of Directors of the American Society of Civil Engineers. The latter society has published recently the list of definitions as one of its manuals of engineering practice.

Definitions of Terms Used in Sewerage and Sewage Disposal Practice

A. B. C. Process (Alum, Blood, Clay).—A method of deodorizing and precipitating sludge by the addition of alum, charcoal, or some other material and clay, to the raw sewage. One of the earliest satisfactory methods of clarification by chemical precipitation.

Activated Sludge.—Sludge settled out of sewage previously agitated in the presence of abundant atmospheric oxygen.

Activated Sludge Method.—See **Activated Sludge Process.**

Activated Sludge Process.—Sewage treatment in which sewage in or flowing through a tank is brought into intimate contact with air and with biologically active sludge, previously produced by the same process. The effluent is subsequently clarified by sedimentation.

Aeration.—The process or method of bringing about intimate contact between air and a liquid by allowing finely divided air to pass through the liquid or the finely divided liquid to pass through air.

Air-Lift.—A device for raising sewage or other liquid by injecting air in and near the bottom of an open discharge pipe submerged in a well of the liquid to be raised.

Alignment.—The direction of the axis of a sewer in plan.

Alternating Device.—A device whereby sewage may be automatically delivered into different parallel treatment units in a cycle following a predetermined sequence.

Appurtenances.—See **Sewer Appurtenances.**

Back-Water Gate.—A device for preventing the back flow of sewage or water.

Baffles.—Deflectors of wood, metal, or masonry placed in flowing liquid to divert, guide, or agitate the flow of such liquid.

Band Screen.—An endless band or belt of wire mesh, bars, plates, or other screening medium, which passes around upper and lower rollers or guides.

Bar Screen.—A screen composed of parallel bars or rods. See, also, **Rack.**

Barn Sewage.—Wash water from stables, considerable quantities of animal wastes.

Basin.—A shallow tank or natural or artificial depression through which liquids pass or in which they are detained for treatment.

Bio-Aeration.—A modification of the activated sludge process in which the sewage and sludge are agitated and aerated by mechanical means, such as paddle-wheels or turbines.

Bio-Chemical Action.—Chemical action resulting from the growth or metabolism of living organisms.

Bio-Chemical Oxygen Demand.—The quantity of oxygen required for biochemical oxidation in a given time at a given temperature, the determinations usually be for 5 days at 20° cent.

Biolytic Tank.—A continuous flow tank with hopper bottom, with inlet arranged so as to agitate the sludge by the entry of sewage at the apex of the hopper-shaped bottom. This agitation tank is sometimes followed by a settling tank in which the sludge is detained until removed.

Bleach.—Calcium hypochlorite. (Bleaching Powder.)

Blow-Off.—A waste-gate or device for discharging accumulated solids or for emptying a depressed sewer.

Branch Sewer.—An arbitrary term for a sewer which receives sewage from a relatively small area.

Branches.—Special forms of vitrified tile and cast iron pipe for making connections to a sewer. They are called Tee-Y, Double-Y, and V, from the shapes. (Synonym, Junction Pieces.)

Broad Irrigation.—The disposal of sewage by application to farm land involving the incidental benefit to crops growing out of the irrigation and fertilization resulting from the application of the sewage. (Differs from sewage farming in that the primary purpose is the disposal of sewage, while the raising of crops is incidental only.) See, also, **Sewage Farming.**

Cage-Screen.—A screen consisting of a cage, with sides of bars, rods, or mesh, so arranged that it may be lowered into the sewage and raised therefrom for cleaning.

Capillary Water.—Water in the interstices of the soil or of a sand filter, which is not lost by draining.

Catch-Basin.—A chamber or well, designed to prevent the admission of grit and detritus into a sewer.

Catch Pit.—See **Grit Catcher.**

Catchment Area.—The area of a water-shed tributary to a lake, stream, or sewer.

Centrifuge.—A device in which sludge is dewatered by rapid rotation and automatically discharged.

Cesspool.—A pit into which household sewage or other liquid waste is discharged and from which the liquid leaches into the surrounding soil, or is otherwise removed.

Chamber.—A general term for a space enclosed by walls or a compartment, often prefixed by a descriptive word as "grit chamber" or "screen chamber" indicating its contents, or "discharge chamber" or "flushing chamber" indicating its office.

Chemical Precipitation.—Sedimentation accelerated by the coagulation of suspended or colloidal matter through the addition of chemicals.

Chlorination.—Treatment with chlorine or bleaching powder for the purpose of disinfection, the retardation of decomposition, or the oxidation of organic matter.

Circumferential Flow.—Flow parallel to the periphery of a circular tank.

Clarification.—The process of removing suspended and colloidal matter from a turbid liquid.

Clarified Sewage.—Loosely used for sewage from which suspended matter has been partly or completely removed.

Coagulation.—The flocculation of colloidal or suspended matter brought about by the addition of some chemical to the liquid, by contact, or by other means.

Coarse-Grained Filter.—General term for contact bed or trickling filter.

Coarse Rack.—A relative term, but generally used when the clear space between bars is 2 in. or more.

Coarse Screen.—A relative term, but generally used when openings are greater than 1 in. in least dimension, except in the case of racks. See, also, **Coarse Rack.**

Coefficient of Imperviousness.—The ratio, expressed decimally, of effectively impervious surface to the total catchment area.

Collecting System.—All sewers from the house to the outfall. See, also, **Sewerage System.**

Colloidal Matter.—Colloids or matter colloidal in character and action.

Colloids.—(1) The finely divided suspended matter which will not settle and the apparently dissolved matter which may be transformed into suspended matter by contact with solid surfaces or preciptated by chemical treatment. (2) Substances which are soluble as judged by ordinary physical tests, but will not pass through a parchment membrane.

Combined Sewer.—A sewer designed to receive both storm and sewage.

Combined System.—A system of sewers, in which sewage and storm water are carried in the same conduits.

Commercially Dry Sludge.—Sludge containing not more than 10 per cent of moisture by weight.

Common Sewer.—A sewer in which all abutters have equal rights.

Compartment.—A chamber in, or a division of, a structure for sewage treatment.

Concentrated Sewage.—A relative term. Sewage containing a relatively large quantity of organic matter.

Conditioning.—See **Sludge Conditioning.**

Contact Aerator.—A device consisting of a crate holding broken stone, coke, brushwood, or other media, which is placed in a single, or two-story sedimentation tank and through which the sewage is made to flow upward and return on the outside and become activated by the admission of compressed air below.

Contact Bed.—An artificial bed of coarse material, such as broken stone or clinkers, in a water-tight basin provided with controlled inlet and outlet. It is operated in cycles of filling with sewage, standing full in contact, emptying, and resting empty, in order to remove some of the suspended matter and oxidize organic matter by bio-chemical agencies.

Contaminated Water.—Water unfit for any given use because of contact with or the presence of injurious substances.

Contamination.—The introduction into water, otherwise satisfactory, of bacteria, sewage, or other substance, which makes it unfit for any given use.

Cover.—See **Manhole Head.**

Crown.—The inside top of a sewer.

Crude Sewage.—Sewage which has received no treatment.

Datum.—Plane of reference for elevations.

Degreasing.—The process of removing fats and greases from sewage, waste, or sludge.

Degree of Purification.—A measure of the removal and oxidation of the objectionable or putrescible contents of sewage.

Depressed Sewer.—A sewer, often crossing beneath a valley or a water course, which runs full or under greater than atmospheric pressure becaues its profile is depressed below the hydraulic grade line.

Detritus Tank or Chamber.—A detention chamber larger than a grit chamber, usually with provision for removing the sediment without interrupting the flow of sewage. A settling tank of short detention period designed, primarily, to remove heavy settleable solids.

Diffuser.—A porous plate or other device through which air is forced and enters the sewage in the form of minute bubbles.

Digestion.—The bio-chemical decomposition of organic matter resulting in the formation of mineral and simpler organic compounds.

Dilute Sewage.—A relative term. Sewage containing a relatively small quantity of organic matter.

Dilution.—(1) A method of disposing of sewage or effluent by discharging into a stream or other body of water. (2) The ratio of the volume of flow of a stream to the volume of sewage or effluent discharged into it.

Direct Oxidation Process.—(So-called.) A proprietary method of treatment in which sewage previously dosed with lime is passed through closed tanks between plate electrodes across which electric current is passing while the liquid is agitated by rotating paddles.

Disc Screen.—A screen in the form of a circular disc rotating about an axis perpendicular to its center.

Discharge Sewer.—See **Outlet Pipe.**

Disinfected Sewage.—Crude sewage, or a sewage plant effluent which has been treated with a disinfecting agent, commonly chlorine or "bleach," resulting in the destruction of bacteria sufficiently to reduce materially the danger of infection.

Disinfection.—The partial destruction, ordinarily by the use of some chemical, or the micro-organisms likely to cause infection and disease.

Dispersion.—A method of disposal of the suspended solids in sewage or effluent by scattering them widely in a stream or other body of water.

Distributor.—A device used to apply sewage to the surface of a filter. There are two general types, fixed and movable. The fixed type may consist of perforated pipe or notched troughs, sloping boards, or sprinkler nozzles. The movable type may consist of rotating or reciprocating perforated pipes or troughs applying spray or a thin sheet of sewage.

Diversion Chamber.—A chamber which contains a device for diverting all or a part of the flow.

Diversion Manhole.—See **Diversion Chamber.**

Domestic Sewage.—Sewage derived principally from dwellings, business buildings, institutions, and the like. (It may or may not contain ground-water, surface water, or storm water. It may also contain a small proportion of industrial waste liquid.)

Dorr Thickener.—(Clarifier.) A proprietary device placed in a tank by which a system of scrapers, driven by a central shaft, revolves slowly, pushing the deposited sludge to a central outlet, from which it is removed by gravity or pumping.

Dortmund Tank.—A vertical-flow sedimentation tank with hopper bottom. The sewage, introduced near the bottom, rises and overflows at the surface, and the sludge may be removed from the bottom before it becomes septic.

Dosing Chamber.—See **Dosing Tank.**

Dosing Siphon.—An automatic siphon for discharging the contents of a dosing tank.

Dosing Tank.—A tank into which raw or partly treated sewage is introduced and held until the desired quantity has been accumulated, after which it is discharged at such a rate as may be necessary for distribution essential to the subsequent treatment.

Drain.—Conduit or pipe, usually underground, for carrying off, by gravity, liquids or other than sewage and industrial wastes, and including ground or subsoil water, surface water, and storm water.

Drainage.—A general term for gavity flow of liquids in conduits. Commonly applied to surface and ground-water.

Drainage System.—A system of drains.

Drainage Water.—Water flowing in a drain derived from ground, surface or storm water.

Drop Manhole.—A shaft in which sewage falls from a sewer to a lower level.

Drum Screen.—A screen in the form of a cylinder or truncated cone rotating on its axis.

Dry-Weather Flow.—Flow of sewage in a sewer during dry weather.

Effluent.—Sewage, partly or completely treated, flowing out of any sewage treatment device.

Effluent Discharge Conduit.—See **Outlet Pipe.**

Ejector.—See **Pneumatic Ejector.**

Emscher Filter.—See **Contact Aerator.**

End Manhole.—One at the up-stream end of a sewer.

Entrance Well.—See **Inlet Well.**

Evaporation.—Vaporization of moisture from a wet surface.

Filtered Sewage.—The effluent of a sewage filter.

Filtering Medium.—The material through which sewage applied to a filter must pass.

Filtration.—(1) The process of removing suspended and colloidal matter from a liquid and the oxidation of its dissolved organic matter, by causing it to flow through a relatively fine porous medium. (2) Sometimes loosely applied to the removal of solids and liquid organic matter in treatment beds.

Filtros.—The trade name applied to an artificial porous stone made of carefully graded silicious sand by moulding, pressing, firing, annealing, and grinding. It is used as a filtering medium and for diffusing air in the activated sludge process.

Final Settling Basin.—A tank through which the effluent of a trickling filter, or other oxidizing device, passes for the purpose of removing the settleable solids before its discharge.

Final Settling Tank.—Same as final settling basin, but deeper and of less area.

Fine Rack.—A relative term, but generally used when the clear space between the bars is 1 in. or less.

Fine Screen.—A relative term, but generally used for a screen with openings ¼ in., or less, in least dimension.

Flaring Inlet.—A funnel-shaped entrance to facilitate flow into a pipe or conduit.

Flotation.—A method of collecting suspended matter in a tank as a scum at the surface by the evolution of gas by chemicals, electrolysis, heat, or bacterial decomposition.

Flowing-Through Chamber.—The upper compartment of a 2-story sedimentation tank.

Flush Tank.—A chamber in which water or sewage is accumulated and discharged at intervals for flushing a sewer.

Flushing Chamber.—See **Flush Tank; Flushing Manhole.**

Flushing Manhole.—A manhole provided with a gate so that sewage or water may be accumulated and then discharged rapidly for flushing a sewer.

Frame.—See **Manhole Head.**

Fresh Sewage.—Sewage of recent origin still containing free dissolved oxygen.

Gas Slot.—See **Gas Vent.**

Gas Vent.—(1) A passage to permit the escape of gases of decomposition. (2) An opening which allows gas, liberated in an Imhoff tank sludge digestion chamber, to reach the atmosphere without passing up through the sewage in the settling chamber.

Grade.—Elevation of invert.

Gradient.—See **Slope.**

Grating.—A screen consisting of parallel bars, two sets being transverse to each other in the same plane.

Gravity System.—A system in which all sewage runs on descending gradients from source to outlet, or where no pumping is required.

Grease Trap.—A device by means of which the grease content of sewage is cooled and congealed so that it may be skimmed from the surface.

Grit.—The heavy mineral matter contained in sewage, such as sand, gravel, cinders, etc.

Grit Catcher.—A chamber usually placed at the upper end of a depressed sewer, or at other points of protection on combined or storm-water sewers, of such shape and dimensions as to reduce the velocity of flow and thus permit the settling out of grit.

Grit-Chamber.—A small detention chamber or an enlargement of a sewer designed to check the velocity of the sewage enough to permit the heaviest solid matter, such as grit, to be deposited with a view to its frequent and easy removal. (Grit Compartment.)

Ground-Water.—Water derived from beneath the surface of the ground.

Ground-Water Drain.—A drain which carries away ground-water.

Horizontal Flow Tank.—A tank or basin, with or without baffles, in which the direction of flow is generally horizontal.

House Connection.—See **House Sewer.**

House Sewage.—(1) Sewage from dwellings. (2) Loosely used for domestic sewage.

House Sewer.—A pipe conveying the sewage from a single building to a common sewer or point of immediate disposal.

Humus Sludge.—(1) Digested sludge deposited in final or secondary settling tanks, following trickling filters or other oxidizing device. (2) Sludge resembling humus in appearance.

Humus Tank.—A tank for collecting humus sludge. See, also, **Final Settling Tank; Final Settling Basin.**

Hydraulic Grade.—The elevation of the surface of the liquid in a sewer above an assumed datum.

Hydraulic Gradient.—The surface slope of the liquid in a sewer. Generally taken parallel to the invert.

Hydraulic Inclination.—See **Hydraulic Gradient.**

Hydraulic Slope.—See **Hydraulic Gradient.**

Hydrolysis.—A change in the molecular composition of matter produced by the addition of water.

Hydrolytic Tank.—In general, any sewage tank in which hydrolysis occurs, specifically applied to a special form of vertical flow tank. General term for any sedimentation tank in which, by bio-chemical processes, a part of the suspended organic matter is liquefied and gasified.

Imhoff Tank.—A deep two-storied tank invented by Karl Imhoff, M. Am. Soc. C. E., consisting of an upper or continuous sedimentation chamber and a lower or sludge digestion chamber. The floor of the upper chamber slopes steeply to trapped slots, through which solids may settle into the lower chamber. The lower chamber receives no fresh sewage directly, but is provided with gas vents and with means of drawing digested sludge from near the bottom.

Industrial Sewage.—Sewage in which industrial wastes predominate. See, also, **Domestic Sewage; Industrial Wastes.**

Industrial Wastes.—Liquid wastes from industrial processes.

Infected Water.—Water which contains pathogenic bacteria.

Infection of Water.—The introduction of pathogenic bacteria into water in sufficient quantities to produce disease.

Infiltration.—The leaching of water from the ground into a sewer.

Influent.—Sewage, raw or partly treated, flowing into any sewage treatment device.

Inlet.—A connection between the surface of the ground and a sewer for the admission of surface or storm water.

Inlet Well.—A well or opening at the surface of the ground to receive surface water which is thence conducted to a sewer.

Institutional Sewage.—Domestic sewage from institutions, such as hospitals, sanitariums, or penal and charitable establishments.

Intercepting Sewer.—A sewer which receives the dry-weather flow from a number of transverse sewers or outlets, with or without a determined quantity or storm water if from a combined system.

Intermittent Filter.—A natural or artificial bed of sand or other fine-grained material to which sewage is intermittently applied in doses and through which it flows, opportunity being given for filtration and also oxidation of the organic matter by bio-chemical agencies.

Invert.—Originally, the inverted arch of a masonry-lined sewer. By derivation, the floor, bottom, or lowest point in the internal cross-section of a sewer.

Invert Block.—A voussoir shaped hollow tile built into the invert of a masonry sewer.

Inverted Siphon Sewer.—See **Depressed Sewer.**

Irrigation.—See, **Sub-Surface Irrigation; Surface Irrigation; Broad Irrigation; Sewage Farming.**

Junction Chamber.—A converging section of a sewer used to facilitate the flow from one or more sewers into a main sewer.

Junction Manhole.—A manhole at the junction of two or more sewers.

Kitchen Waste.—Liquid culinary wastes.

Lamp-Hole.—A small vertical pipe or shaft leading from the surface of the ground to a sewer, for admitting a light for purposes of inspection.

Land Drain.—A drain for drawing off water from land. See, also, **Ground-Water Drain.**

Lateral Sewer.—A sewer which discharges into a branch or other sewer and has no other common sewer tributary to it.

Leaching Cesspool.—A cesspool out of which the liquid leaches into the surrounding soil.

Line Manhole.—A manhole in the line of a sewer at a point where no other sewers connect. It may be at a point where the sewer changes direction, either in line, slope, or grade.

Liquid Sludge.—Sludge containing sufficient water to permit it to flow by gravity (ordinarily above 80 per cent).

MacLachlan Process.—(A Proprietary Process.) A method of conditioning sludge preparatory to dewatering by the application of sulfur dioxide gas.

Main Sewer.—A sewer which receives one or more branch sewers as tributaries.

Manhole.—A shaft, or chamber, from the surface of the ground to a sewer, large enough to enable a man to have access for the purpose of inspection and cleaning.

Manhole Head.—The cast-iron fixture surmounting a manhole. It is made up of two parts: A "Frame" which rests on the masonry of the shaft, and a removable "Cover." Frames are either "Fixed" or "Adjustable" in height. Covers are "Tight," "Ventilated," or "Anti-Rattling."

Medium Screen.—A screen having openings intermediate between those of a coarse and a fine screen.

Mesh Screen.—A screen composed of woven fabric, usually of wire.

Miles Acid Process.—A proprietary method of treatment invented by George W. Miles, in which sewage is acidified by sulfurous acid fumes. The fumes are absorbed by a part of the sewage. This part is then mixed with the remainder of the sewage. Subsequent precipitation of solids results in clarification and a measure of disinfection.

Outfall Sewer.—A sewer which receives the sewage from the collecting system and conducts it to a point of final discharge or to a disposal plant.

Outlet Pipe.—A pipe which conveys the effluent from a treatment plant to its final point of disposal.

Oxidation.—See **Sewage Oxidation.**

Oxidized Sewage.—Sewage in which the organic matter has been combined with oxygen and has become stable.

Percolating Filter.—See **Trickling Filter.**

Percolation.—The flow or trickling of a liquid downward through a relatively coarse filtering medium. The liquid usually does not fill the pores of the medium.

Plate Screen.—A screen composed of one or more perforated plates.

Pneumatic Ejector.—A means of raising sewage, other liquid, by alternately admitting it through a check-valve into the bottom of a pot and then ejecting it through another check-valve into the discharge pipe, by admitting compressed air to the pot above the liquid.

Polarite.—Magnetic spongy carbon, formerly used as a filter medium after sedimentation.

Polluted Water.—Water made unclean or injured by sewage, industrial waste, or other substance.

Pollution.—The act of making unclean or impure or the state of being unclean or impure as a result of admixtures of sewage, industrial wastes, or other substance.

Precipitation.—Rain and snowfall. See, also, **Chemical Precipitation.**

Private Sewer.—One privately owned and used by one or more properties.

Public Sewer.—A common sewer controlled by public authority.

Putrefaction.—Biological decomposition of organic matter with the production of ill-smelling products. It occurs under conditions of oxygen deficiency.

Putrescibility.—(1) The susceptibility of waste waters, sewage, effluent, or sludge to putrefaction. (2) The relative tendency of organic matter to undergo decomposition in the absence of oxygen.

Rack.—A screen composed of parallel bars, either vertical or inclined, from which the screenings may be raked.

Radial Flow.—Direction of flow across a circular tank, from center to periphery, or vice versa.

Radial Inward Flow.—Inlet at periphery and outflow at the center of a circular tank.

Radial Outward Flow.—Inlet at center and outflow at the periphery of a circular tank.

Rainfall Rate.—Precipitation, generally expressed in inches per hour.

Rate of Precipitation.—See **Rainfall Rate.**

Raw Sewage.—See **Crude Sewage.**

Receiving Basin.—See **Inlet Well.**

Regulator.—A device for controlling the quantity of sewage admitted to an intercepting sewer or unit of a disposal plant.

Relative Stability.—The ratio, expressed in percentage, of available oxygen in waste waters, sewage, effluent, or diluted sewage to that required to provide complete bio-chemical oxidation of the organic matters contained therein.

Relief Sewer.—A sewer built to relieve an existing sewer of inadequate capacity.

Reservoir.—A tank or basin primarily for storage of a liquid.

Roof Water.—Storm water from roofs.

Run-Off.—That part of the rainfall which reaches a stream, drain, or sewer.

Run-Off Coefficient.—The ratio, expressed decimally, of run-off to precipitation.

Run-Off Rate.—An expression of the rate at which rainfall runs off from a surface, expressed in inches in depth of rainfall per hour, cubic feet per second, or other units.

Sand Catcher.—See **Grit Catcher.**

Sand Filter.—A filter in which sand is the filtering medium. See, also, **Intermittent Filter.**

Sanitary Sewage.—(1) Domestic sewage with storm water excluded by design. (2) Sewage originating in the sanitary conveniences of a dwelling, business building, factory, or institution. (3) The water supply of a community after it has been used and discharged into a sewer.

Sanitary Sewer.—A sewer which carries sewage and excludes storm, surface, and ground-water.

Saturation.—The condition of a liquid when it has taken into solution the maximum possible quantity of a given substance at a given temperature and pressure, as water saturated with oxygen.

Screen.—A device with openings, generally of uniform size, used to retain coarse sewage solids. The screening element may consist of parallel bars, rods, or wires, grating, wire mesh, or perforated plate, and the opening may be of any shape, generally circular or rectangular slots.

Screening.—The removal of relatively coarse floating and suspended solids by straining through racks or screens made of bars, gratings, wires, or perforated plates.

Screenings.—Material removed from sewage by screens and racks.

Scum.—A mass of sewage solids, buoyed up by entrained gas, grease, or other substance, which floats at the surface of sewage.

Scum Board.—A vertical baffle dipping below the surface of sewage in a tank to prevent the passage of floating water.

Secondary Settling Tank.—See **Final Settling Tank.**

Sedimentation.—The subsidence and deposition of suspended matter in a liquid by gravity.

Sedimentation Tank.—A tank or basin in which sewage, partly treated sewage, or other liquid containing settleable solids, is retained long enough, and in which the velocity is low enough, to bring about sedimentation of a part of the suspended matter, but without a sufficient detention period to produce anaerobic decomposition.

Semi-Circumferential Flow.—Flow parallel to the semi-circumferences of a circular tank, divided at the inlet and meeting again at the common outlet.

Separate Sludge Digestion.—The digestion of sludge in basins or tanks to which it is removed from the basins or tanks in which it originally settled.

Separate System.—A system of sewers in which sewage and storm water are carried in separate conduits.

Sept-Aer-Sed Method.—Sewage treatment in which septic tank effluent is aerated and passed into a sedimentation tank. The sludge from the sedimentation tank is then pumped back into the septic tank.

Septic Sewage.—Sewage undergoing putrefaction in the absence of oxygen.

Septic Tank.—A settling tank intended to retain the sludge in immediate contact with the sewage flowing through the tank for a sufficient period to secure a satisfactory decomposition of organic solids by anaerobic bacterial action.

Settleable Solids.—Suspended solids which will subside in quiescent sewage in a reasonable period. (Two hours is a common arbitrary period.)

Settled Sewage.—Sewage from which some of the solids have settled out in a tank during quiescence or slow flow.

Settling Chamber.—(1) The second or final element of the so-called biolytic tank. (2) Sometimes used to designate the sedimentation compartment of a 2-story tank, as in the case of the Imhoff tank. See, also, **Sedimentation Tank.**

Settling Solids.—See **Settleable Solids.**

Settling Tank.—See **Sedimentation Tank.**

Sewage.—(1) Wash water and water-carried animal, culinary, and, in some cases, industrial wastes. (2) Liquid waste containing human excreta, and other matter, flowing in or from a house drainage system or sewer. Excreta includes feces, urine, secretion from the skin, expectoration, etc. (3) Liquid wastes from dwellings and institutions, stables and business buildings. It may also contain liquid wastes from industries. (4) A combination of (a) the liquid wastes conducted away from residences, business buildings, and institutions, and (b) from industrial establishments, with (c) such ground, surface, and storm water as may be admitted to or find its way into the sewers. (5) The ordinary liquid contents of a sewer containing organic wastes, which may or may not include street wash.

Sewage Disposal.—General term. The act of disposing of sewage by any method.

Sewage Farming.—A term applied to the raising of crops where sewage is applied to the land for irrigation and fertilization purposes. See, also, **Broad Irrigation.**

Sewage Oxidation.—The process whereby through the agency of living organisms in the presence of oxygen, the organic matter is converted into a more stable or mineral form.

Sewage Purification.—(1) The removal or mineralization of all putrescible organic matter and the removal of all infectious and offensive matter. (2) Loosely used for Sewage Treatment.

Sewage Treatment.—Any artificial process to which sewage is subjected in order to remove or so alter its objectionable constituents as to render it less offensive or dangerous.

Sewage Treatment Works.—Treatment plant and means of disposal.

Sewer.—A pipe or conduit, generally closed, but normally not flowing full, for carrying sewage and other waste liquids.

Sewer Appurtenances.—Constructions, devices and appliances other than the pipe or conduit, which are appurtenant to a sewer, such as manholes, flush tanks, surface inlets, etc.

Sewer Arch.—The curved top of a masonry sewer.

Sewer Outfall.—The structure at the lower end of an outfall sewer.

Sewer District.—The area deemed benefited by the construction and use of sewers.

Sewer Inlet.—See **Inlet Well.**

Sewer Territory.—See **Sewer District.**

Sewerage System.—A collecting system of sewers and appurtenances.

Sewerage Treatment Works.—See **Sewage Treatment Works.**

Sewerage Works.—Comprehensive term, including all construction for collection, transportation, pumping, treatment, and final disposition of sewage.

Sheffield System.—A method of activating sludge by the rotation of paddle-wheels placed at intervals in a long and relatively narrow and shallow tank.

Side-Walls.—The vertical, curved, or inclined walls which support the arch or top of a masonry sewer.

Simplex Process.—A process for activating sludge by the circulation of sewage up through a central tube, dispersing it by the rotation of an inverted cone suspended above, and permitting a downward return outside the tube.

Sink Water.—Liquid waste from a sink.

Skimming Tank.—A chamber so arranged that floating matter rises and remains on the surface of the sewage until removed while the liquid flows out continuously under partitions, curtain-walls, or scum boards.

Slant.—A branch inserted in a sewer for the purpose of making connection thereto.

Sleek.—The thin oily film usually present which gives characteristic appearance to the surface of water into which sewage or oily waste is discharged.

Slope.—The inclination of the invert of a sewer expressed in percentage of length, as a decimal, or as 1-ft. fall in a given length of feet.

Slot.—A narrow opening.

Sludge.—The accumulated suspended solids of sewage deposited in tanks or basins, mixed with more or less water to form a semi-liquid mass.

Sludge Bed.—Natural or artificial layers of porous material upon which sludge is dried by drainage and evaporation.

Sludge Cake.—A mass resulting from sludge pressing, or vacuum filtering.

Sludge Chamber.—See **Sludge Digestion Chamber.**

Sludge Compartment.—See **Sludge Digestion Chamber.**

Sludge Concentration.—Any process of reducing the water content of sludge which leaves it still in a liquid condition.

Sludge Conditioning.—Treatment of liquid sludge preliminary to, and to facilitate, de-watering.

Sludge De-Watering.—A general term for the removal of a part of the water in sludge by any process, such as draining, pressing, centrifuging, exhausting, passing between rollers, or acid flotation, with or without heat. It involves reducing from a liquid to a spadable condition rather than merely changing the density of the liquid (concentration) on one hand, or drying (as in a kiln) by high heat on the other.

Sludge Digestion.—The bio-chemical process by which organic matter in sludge is gasified, liquefied, mineralized, or converted into more stable organic matter.

Sludge Digestion Chamber.—(1) Any chamber used for the digestion of sludge. (2) The lower story of an Imhoff tank or Travis tank.

Sludge Drying.—The process of drying sludge by drainage or evaporation, by exposure to the air, or by application of heat.

Sludge-Drying Bed.—See **Sludge Bed.**

Sludge Pressing.—Process of de-watering sludge by subjecting it to pressure, the solids being retained, usually by a cloth fabric through which the water passes.

Spadable Sludge.—Sludge dry enough to be shoveled from the drying bed. (Ordinarily under 70 per cent moisture.)

Spiral Flow Tank.—A tank used in carrying out the activated sludge process in which a spiral motion is given to the sewage in its flow through the tank by the introduction of air through a line of diffusers placed on one side of the bottom.

Spray Nozzle.—See **Sprinkler Nozzle.**

Spraying Nozzle.—See **Sprinkler Nozzle.**

Sprinkler.—See **Sprinkler Nozzle.**

Sprinkler Nozzle.—A nozzle used for applying sewage in the form of a spray to a trickling filter.

Sprinkling Filter.—A trickling filter in which the sewage is applied by spray.

Squeegee.—A device, generally with a soft rubber edge, used for dislodging and removing deposited sewage solids from the walls and bottoms of settling tanks.

Stability.—The ability of any substance, such as sewage, effluent, or digested sludge, to resist putrefaction. (Antonym, Putrescibility.)

Stable Effluent.—A treated sewage which contains enough oxygen to satisfy its oxygen demand.

Stale Sewage.—Sewage containing little or no oxygen, but as yet free from putrefaction.

Stench Trap.—A flap in a frame which opens to admit cellar drainage to a sewer and then closes to prevent sewer air from entering the house.

Sterlization.—The destruction of all micro-organism ordinarily through the agency of heat or of some chemical.

Sterilized Sewage.—A sewage effluent in which all micro-organisms have been destroyed.

Storm Drain.—See **Storm Sewer.**

Storm Overflow.—A weir, orifice, or other device for permitting the discharge from a combined sewer of that part of the flow in excess of that which the sewer is designed to carry.

Storm Overflow Sewer.—A sewer used to carry the excess of storm flow from a main or intercepting sewer to an independent outlet.

Storm Sewage.—Liquid flowing in sewers during or following a period of rainfall and resulting therefrom.

Storm Sewer.—A sewer which carries storm and surface water, street wash, and other wash waters, or drainage, but excludes sewage.

Storm Water.—Excess water during rainfall or continuously following and resulting therefrom.

Storm-Water Drain.—See **Storm Sewer.**

Storm-Water Overflow.—See **Storm Overflow.**

Storm-Water Overflow Sewer.—See **Storm Overflow Sewer.**

Street Sewer.—Common sewer or public sewer in a street. See, also, **Common Sewer; Public Sewer.**

Strong Sewage.—Sewage containing above the normal quantity of organic matter.

Sub-Drain.—A drain built beneath a sewer to intercept ground-water and prevent it from entering the sewer, especially during construction.

Sub-Grade.—The elevation of the bottom of a trench in which a sewer or drain is laid.

Sub-Main Sewer.—An arbitrary term for relatively large branch sewers.

Subsiding Basin.—See **Sedimentation Tank.**

Subsoil Drain.—A land drain deep enough to take water from the subsoil.

Sub-Surface Irrigation.—The process of sewage treatment in which sewage or effluent is applied to land by distributing it beneath the surface through open jointed pipes or drains.

Surface Inlet.—See **Inlet Well.**

Surface Irrigation.—The process of sewage irrigation in which sewage is applied to and distributed over the surface of the ground.

Surface Water.—Water which flows upon or over the surface of the ground.

Surface-Water Drain.—A drain which carries surface water.

Suspended Matter.—Solids physically suspended in sewage or effluent.

System of Sewerage.—See **Sewerage System.**

System of Sewers.—See **Sewerage System.**

Tank.—Any artificial receptacle through which liquids pass or in which they are detained during collection or treatment.

Tight Cesspool.—See **Water-Tight Cesspool.**

Tight Manhole Cover.—A manhole cover without openings.

Trade Wastes.—British expression for industrial wastes. See, also, **Industrial Wastes.**

Trap.—A device to prevent sewer air from backing up and escaping through a plumbing fixture. When made of cast iron or vitrified tile, it may be of various forms defined as running trap, P-trap, S-trap, etc.

Trash.—The material removed from combined and storm-water sewers by coarse racks.

Travis Tank.—A two-story hydrolytic or septic tank invented by Dr. Travis, consisting of an upper sedimentation chamber with steeply sloping bottom terminating in slots through which the deposited solids pass into a lower or sludge digestion chamber through which latter a predetermined part of the sewage is allowed to pass for the purpose of seeding and maintaining bacterial life in the sludge and carrying away decomposition products. This is for the purpose of inducing digestion of the sludge attended by its reduction in volume.

Treated Sewage.—Sewage which has received more or less complete treatment.

Trickling Filter.—An artificial bed of coarse material, such as broken stone, clinkers, slate, slats, or brush, over which sewage is distributed and applied in drops, films, or spray, from troughs or drippers, moving distributors, or fixed nozzles, and through which it trickles to the under-drains giving opportunity for organic matter to be oxidized by bio-chemical agencies.

Trunk Sewer.—A sewer which receives many tributary branches and serves as an outlet for a large territory. See, also, **Main Sewer.**

Twin or Multiple Dosing Tanks.—Twin or multiple tanks of equal capacity, each equipped with a dosing device, which devices are usually so inter-connected that they fill and discharge alternately, or in rotation.

Under-Drain.—A land drain laid below the surface of the ground, or of a sand filter or sludge bed. See, also, **Sub-Drain.**

Ventilated Manhole Cover.—A manhole cover with openings.

Vertical Flow Tank.—A sedimentation tank in which the sewage enters near the bottom, rises vertically, and flows out at the top.

Water-Tight Cesspool.—A cesspool with tight walls to prevent leaching and from which the contents are removed at intervals.

Weak Sewage.—See **Dilute Sewage.**

Wing Screen.—A screen in which the screening elements are radial planes or curved vanes rotating on a horizontal axis.

Maintenance of Sanitary Sewers and Storm Drains

The methods employed on the sewer system of Baltimore, Md., were described in *Municipal News and Water Works* by Milton J. Ruark, Sewerage Engineer, Bureau of Sewers, as follows:

The need for maintaining sewers and drains is usually the result of one or more of four causes: Poor design, poor construction, depreciation, and in some respects the most important of all—misuse.

Poor Design.—The question of the poor design of sewers in Baltimore, where careful study and thought are devoted to relatively unimportant sewer projects, is practically of no importance insofar as the maintenance of the sewers is concerned. Care must be given in selecting the proper materials for construction, and sewers of adequate size and strength should be planned. Except where unusual problems present themselves, the planning of sewers and drains has become so standardized that there is little excuse for poor designs.

Poor Construction.—It is as essential to have good construction as it is to use careful design in order that maintenance costs may be kept at a minimum. Two of the most essential things to watch in the construction of sewers is to see that the material used for backfill is thoroughly compacted under and around the pipe and that the joints are well made. The former precaution will add much to the strength of the sewer, and tend to prevent failures.

A Root Proof Joint.—Tight joints not only reduce the quantity of ground water entering the sewers to a minimum but also help to exclude tree roots. Fully 35 per cent of the chokages in the sanitary sewers of Baltimore are due to the roots of poplar and willow trees. Many times roots grow long distances to reach sewers. The roots of oak and similar shade trees have never been known to give this trouble. In each place where a sewer becomes choked because of tree roots the joints, through which the roots have passed, are remade with great care. First, a ring of jute is inserted in the bell of the pipe the same as when the usual Portland cement joint is made. Then red and puddle clay, to which has been added a liberal quantity of coarse salt, is packed over the jute to within about ½ in. of the end of the bell. On top of this is placed a mortar of cement and sand. This type of joint has proved effective, since none has ever been replaced because of the entrance of tree roots.

Maintenance Due to Depreciation.—The maintenance required to keep a sewer system in first-class condition is usually not great, especially if the system is new. However, there are numerous factors which tend to increase the gradual depreciation of sewers. Other public utilities such as gas and water pipes, electric conduits, etc., are often constructed in trenches adjacent to the sewers, and not infrequently the latter are damaged due to a settlement of earth or other causes. It is sometimes weeks or months before the trouble is discovered and rectified.

The tapping of sewers by plumbers to provide for additional house connections often causes trouble that makes itself evident by a chokage near the tap. One way to remedy this difficulty is to inspect thoroughly every new connection.

A great deal of the general maintenance work consists in replacing noisy and broken manhole covers and making repairs to inlets. Where sewers are well designed and constructed, and are not old, little money need normally be appropriated or spent to remedy wear and tear.

Maintenance Due to the Misuse of Sewers.—Although a sewer system is designed to have a very limited use, it usually becomes the repository for almost conceivable object of moderate size. The following is a list of some of the things which have been removed from choked sewers: Hatchets, bricks, bird cages, corn cobs, flat irons, pick handles, dish pans, shoes, oyster shells, table spoons, broom handles, whiskey flasks, brushes, garden hose, coffee pots, dead cats and dogs, dolls, etc. It seems inconceivable how some of these objects get into the sewers.

Maintenance of Storm Drains.—One of the first rules that must be followed in order to reduce the maintenance of storm drains is to keep the streets clean. Unless this policy is followed the debris on the street is washed into the drains after the first heavy rain, where it often has to be removed at considerable cost.

Furthermore, the material at dumps, the drainage from which flows into the upstream end of storm sewers, should be kept from rolling or obstructing the drains.

Disposal of Snow Into Drains.—In most large cities the disposal of snow into storm drains has become a generally accepted practice. Frequently the snow has mixed with it garbage, ashes and debris found on the streets. The snow melts in the drain and often leaves these foreign materials, which have to be eventually removed, stranded on the bottom of the sewers. Large drains should be selected for the disposal of snow, and liberal quantities of water used for flushing purposes.

Disposal of Oil and Gasoline in Drains.—One of the most serious problems that confronts engineers who have charge of the maintenance of sewerage systems relates to the disposal of gasoline and oil from automobile crankcases into the sewers. The problem is an ever present one not only in Baltimore but also in practically every large municipality in the country. Many cities have had serious explosions because of the ignition of gasoline in the sewers. Some cities employ private concerns to collect and dispose of waste oil and gasoline from garages.

Maintenance of Sanitary Sewers.—The maintaining of the sanitary sewers usually consists of removing obstructions from the smaller pipes—usually 8 and 10 in. in diameter. On rare occasions a 12 in. sewer will become clogged, and only once or twice during recent years has a 15 in. sewer been obstructed. Where the larger sewers require cleaning, it is usually due to wastes from industries.

All obstructions in main line and house sewers up to the building line are removed by the city. On the other hand, chokages in the house sewers inside the property lines are removed by a plumber employed by the property owner. This rule, although a rigid one, is not necessarily adhered to in emergencies. In case the difficulty is due to the carelessness of the property owner he is required to pay for all of the expense involved.

Cleaning Tools.—A wise selection of cleaning tools greatly decreases the cost of maintaining sewers. The first essential is to have good cleaning rods. Two types are used in Baltimore. The rods used to clean out storm drains are made of wood, 3 ft. long, octagonal in shape, and about 2 in. thick. They have the advantage of being strong, and at the same time sufficiently light to float on the water while they are being shoved through the drain.

The other rods, which are used to clean sanitary sewers, are 4 ft. long with a cross-section of 1⅛x⅞ in. Other tools, such as scoops, root cutters, etc., are also of value. One of the greatest time and money saving devices for cleaning sewers has been flexible steel cables. They are narrow but strong ribbons of steel, which are used primarily to clean house sewers. At the end of the cable there are two small steel rollers, which increase the ease with which it can be forced through the sewer. The use of this cable has saved property owners thousands of dollars, which formerly was spent in tearing up and replacing the sewers.

Personnel.—The cleaning of the sanitary sewers and storm drains is under the supervision of one man. As previously stated, there is one gang of five men with a truck which spends all its time in cleaning large storm drains. There are four additional gangs with four men in each gang—each provided with a truck—which clean inlets, report and replace broken and noisy manhole covers and do other work. Each of these gangs is alloted a section of the city which it particularly patrols and is responsible for. There is, moreover, a gang of nine men, which makes repairs both to storm drains and sanitary sewers.

The sanitary sewers are maintained by nine groups of men. Four of these groups, consisting of 18 men and two foremen, relieve chokages on main line sewers, while the remaining five groups, having a total of 10 men and one foreman, relieve house sewer chokages. In addition to the above force there are two men who are on duty on Sundays and holidays and also each day from 4 P. M. until midnight. They take care of any emergency that arises after working hours.

Cost of Sewer Maintenance.—The total cost of maintaining 1,560 miles of sanitary sewers and storm drains during 1927 was approximately $158,000. Of this amount $65,000 was spent on 1,000 miles of sewers and house connections at a cost of $65.50 per mile and $92,500 on 560 miles of drains at about $165 a mile.

YEOMANS BROTHERS COMPANY

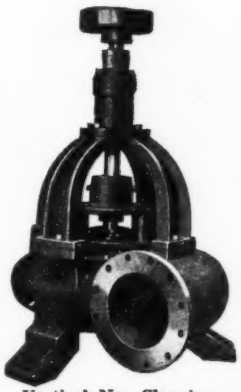
1439 Dayton Street, Chicago, Ill.

Manufacturers of Sewage Ejectors and Pumping Machinery

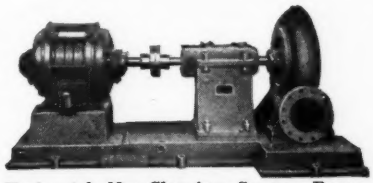
Representatives in all principal cities

Products: CENTRIFUGAL SEWAGE PUMPS, PNEUMATIC SEWAGE EJECTORS, BILGE OR SUMP PUMPS, ROTARY AIR COMPRESSORS, BOOSTER PUMPS, CONDENSATION PUMPS, SPECIAL PUMPS.

Yeomans Non-Clogging Centrifugal Pumps for Unscreened Sewage: Vertical and horizontal dry pit non-clogging machines for pumping crude sewage from low-level districts to gravitation sewers, from sewers to sedimentation tanks or for effluent or sludge in disposal works. The



Vertical Non-Clogging Sewage Pump



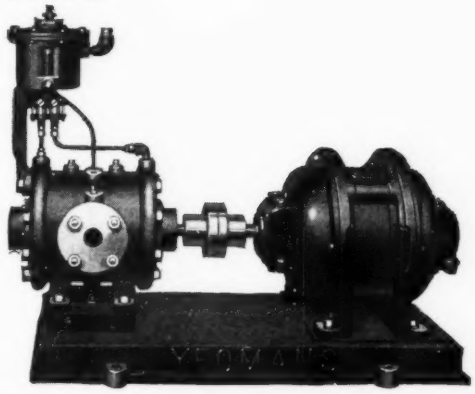
Horizontal Non-Clogging Sewage Pump

pumps are equipped with the specially designed Yeomans impeller which will readily handle solids almost as large as the discharge orifice in the pump casing. No screens are required.

In the vertical pump, the top plate can be raised on the shaft to give access to the interior of the casing without disturbing shaft, impeller or bearings. An exclusive Yeomans feature. Both types absolutely dependable and fool-proof. Write for bulletin S-6100.

Yeomans High Speed Direct-Connected Rotary Air Compressors: A new type of rotary air compressor developed by Yeomans primarily for use with the Shone Ejector, but also highly efficient for activating sludge, air lift systems, priming duty in water-works and any other air service where the pressure requirements do not exceed 50 pounds.

It is quiet running, direct-connected, has little wear and eliminates all belts, gears, pulleys and valves. Write for Bulletin AC-7000.

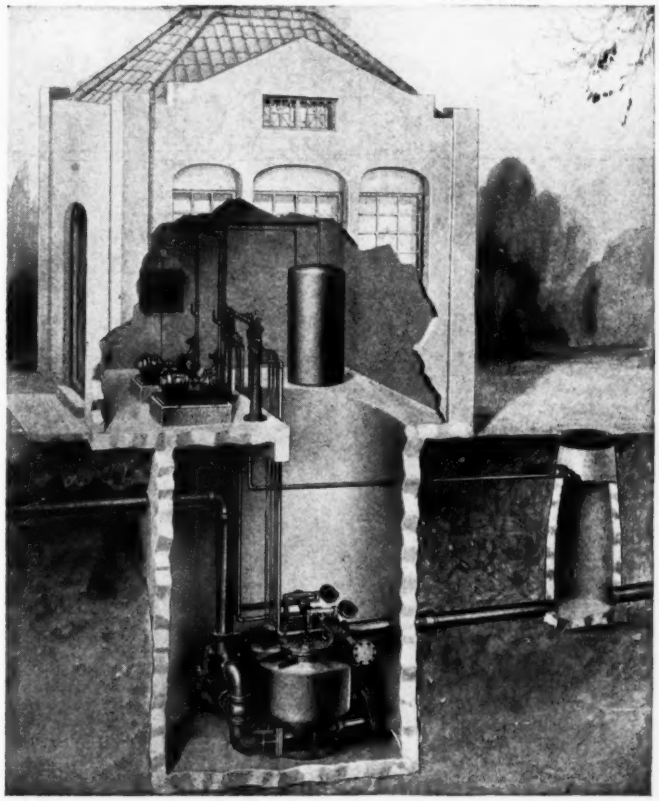


Rotary Air Compressor—No Belts, Gears, Pulleys, Valves

The Shone System of Pneumatic (Screenless) Sewage Ejectors: The oldest and most reliable device on the market for pumping unscreened crude sewage from low-level districts where gravity flow is not obtainable; for effluent or sludge in disposal works; for sewage and drainage from basements below sewer level in city buildings, industrial and power plants, especially where compressed air is required for other purposes. Rotary compressors, shown below, permit operation without storage tank.

The Shone was invented fifty years ago by Isaac Shone, noted English engineer, and since then, with few changes in design, it has been accepted as standard by leading engineers throughout the world.

Among notable installations may be mentioned the city of Cairo, Egypt, in which 63 Shone Ejector stations handle



A Typical Municipal Shone Pneumatic Duplex Ejector Station with Yeomans Rotary Compressors

the entire sewage flow of the city; Rangoon, India, with 13 installations; Bombay, India, 10 installations; Cape Town, South Africa; Rio de Janeiro, Brazil; Ostend, Belgium; Lille, France; Sidney, New South Wales; Moscow and Kiev, Russia; and many other cities.

Operated by Compressed air, the Shone is a purely mechanical device, automatic, sanitary, durable, requiring minimum attention. It has no screens, no storage chambers, no electric float switches. Write for bulletin P-4400.

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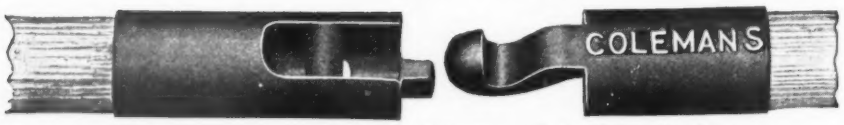
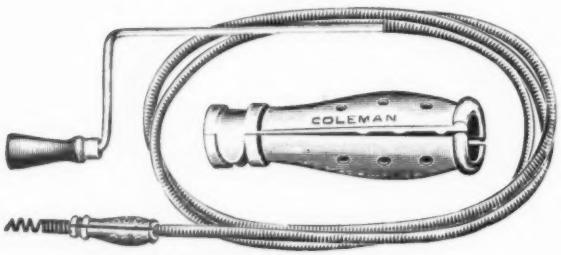
CLOSET AND PIPE CLEANING DEVICES
Will Remove All Stoppages from Pipes and Sewers



Conduits and Sewer Rods and Tools: Made from the best Hickory Rod. Dia. 1⅛ in., 3 ft. and 4 ft. lengths—Malleable Couplings.



Flexible Coil Wire Pipe Augers, 7 Sizes—All Lengths. With Automatic Grip Handles

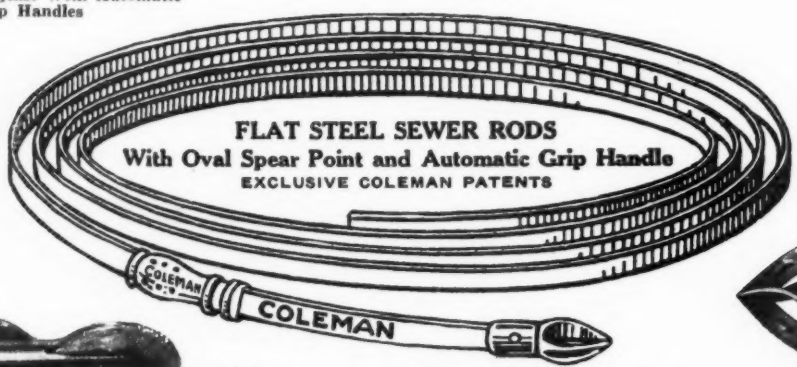
No Municipal Tool Room completely equipped without these Tools and Devices.

Plunger C-543b **Root Cutter C-543c** **Screw C-543d** **Claw C-543e**

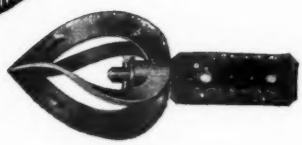
Tools to be used with Conduit and Sewer Rods.

No trouble opening DRAINS if you have these Tools

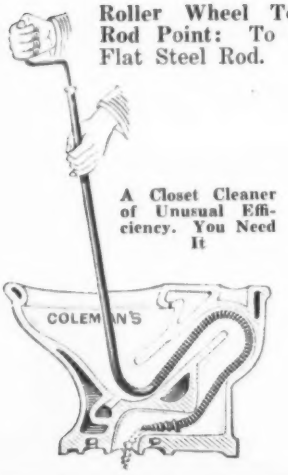
They will save you money.



Made from the best Spring Steel—six sizes, all lengths—1/16" and ⅛" thick.



Revolving Spear Point: Three sizes to be used with Flat Steel Rod.



Roller Wheel Torpedo Sewer Rod Point: To be used with Flat Steel Rod.

A Closet Cleaner of Unusual Efficiency. You Need It

Illustrated here are a few of COLEMAN'S very useful Closet, Pipe, Sewer and Drain Cleaning Tools.
With these Cleaning Devices it is easy to keep your Pipes and Drains Sanitary.
There are no better tools made for this purpose.
Can be purchased through any supply house.
If they will not furnish our high grade tools—order direct!
You take no chances when you place your order for COLEMAN'S—they are guaranteed to please.

Coleman's Sewer or Basin Dip

COLEMAN'S Lead Joint Runner: All clamps have pouring funnels and asbestos rope. Furnished for all sizes of pipe.

PETERSEN'S HYDRAULIC SEWER FLUSHER CO.

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Factory and Sales Office at 277 First Ave., Milwaukee, Wis.

Manufacturers of Sewer Pipe Flushers, Hose Clamps and Equipment

Products: SEWER PIPE FLUSHERS, HOSE CLAMP AND EQUIPMENT.

The Petersen Hydraulic Flushers or Expansion Nozzles are Nationally Recognized as the Most Economical Way for Clearing Sewers.

Petersen Hydraulic Flushers eliminate the expense of digging up or taking out drains and will clear a drain in a few minutes.

Connect the FLUSHER to the flushing hose, place it into the drain, any distance desired, the same as an ordinary nozzle. The FLUSHER is very flexible and small, compared to the size of the drain, and will adapt itself to any shape when under pressure, closing up the drain, giving direct water power against the obstructions, preventing the man from getting socked and allow a heavy flow from its nozzle, which fills the drain to the clog. The volume of water

Style A

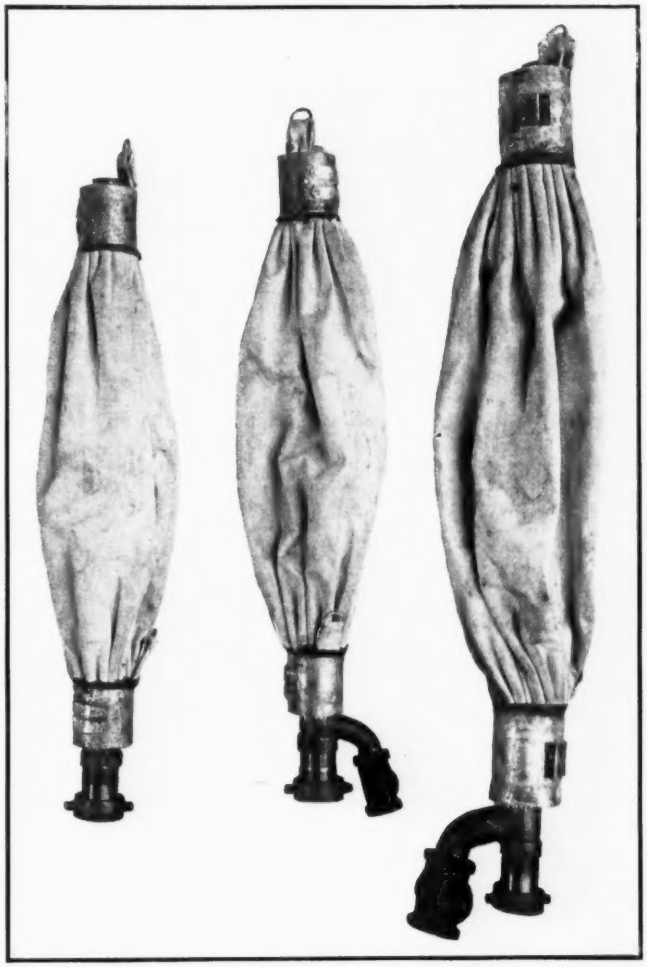
and pressure created removes the obstruction and washes it out. The FLUSHER can also be used to stop the flow of the sewer when repairs are needed.

The Backwater Flush is recommended by many cities using the HYDRAULIC FLUSHER. It is simple. Connect the Flusher to the hose, place the Flusher against the stream in the sewer, turn on the water and it will close up the sewer, then go several blocks upstream, place another FLUSHER and cap the nozzle, turn on the water and you have two streams to raise the water quickly between the FLUSHERS. If you can raise the water a few feet in the manhole, release the first FLUSHER by shutting off the water and open the shut-off which will release the Flusher and empty the water from the hose and bag. For a moment you would believe you had Niagara Falls connected to the sewers and it will be cleared out for many blocks, the MOST MODERN way to clear a sewer.

Style A has a standard hose coupling, or can be furnished in any size coupling. The nozzle is threaded and can be used for a plug by applying a standard 2-in. cap, or reduced when low pressure is used. It is made of heavy grade canvas, 5 ply, a labor saving tool for city, manufacturers and contractors.

Style B has a hose coupling which can be taken off and exchanged with any coupling screw off the shank and the coupling is off and you can place on a new coupling if desired without hurting the flusher. The flusher is made from 6-ply heavy grade canvas and waterproof tubing, from stock number 27 to 29, inclusive.

Style C has an exchangeable coupling which can be taken off. It also has the shut-off. When the instrument is used

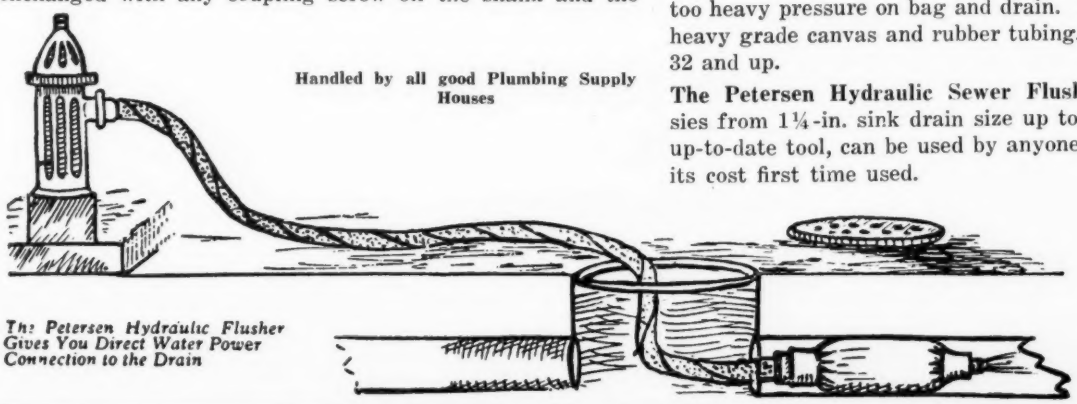


Style B Style C

for a plug, apply a 2-in. cap on the nozzle, open the shut-off and it will release the flow instead of the nozzle, preventing too heavy pressure on bag and drain. It is made from 7 ply heavy grade canvas and rubber tubing. From stock number 32 and up.

The Petersen Hydraulic Sewer Flushers are made in all sies from 1¼-in. sink drain size up to 48-in. It is a strictly up-to-date tool, can be used by anyone and saves more than its cost first time used.

Handled by all good Plumbing Supply Houses



The Petersen Hydraulic Flusher Gives You Direct Water Power Connection to the Drain

If your dealer will not furnish you, order direct.

The Operation of Sewage Treatment Plants

T. C. Schaetzle, Senior Assistant Sanitary Engineer, Maryland State Department of Health, gives the following in *Water Works:*

Sewage treatment plants are installations designed and constructed by man for the purpose of bringing about nature's changes as rapidly as possible, with a minimum of odor and other nuisances, and to prevent pollution of the water courses into which the treated sewages are discharged.

Operator's Duties.—To obtain these two objectives all sewage plants must be run on a strictly business basis. The operator may be likened to a factory manager, the treatment units to the office, machine shop, etc., while the bacterial, chemical and biochemical agents are the "workmen." No business manager would fail for a week, a day, or even an hour to assure himself that all details of the factory operation are receiving proper attention. In like manner, no sewage plant operator can afford to neglect his plant, no matter how small it may be. It must receive daily attention and the sooner those of us connected with this phase of sanitation realize that every sewage treatment unit needs definite daily attention, so that the unseen forces may produce the best results, the sooner will our operating difficulties be lessened.

Designing Engineer's Obligations.—The claim is often made that this or that plant would produce better results if properly operated. While it is true that many plants may not receive the best attention, yet operators have a just cause in their complaint that the engineer designs and builds the plant and then forgets it, never returning to learn how it is funtioning. I believe that the designing engineers could materially help this situation if all of them would attempt to bind their client, be it municipality, industry or institution, to a contract retaining them for a few years to supervise the plant operation.

Furthermore, city authorities frequently have the opinion that when a sewage-treatment plant is installed, the problem is solved and the trouble ended. This is unfortunate, as often the man selected as the operator is underpaid, receives little instruction in his duties, or, in the smaller communities, is assigned to one or more positions, so that the sewage plant work is done mechanically, if at all.

Likewise the average citizen does not know of the existence of a sewage plant, or if he does, it is the last place on earth he cares to visit. Until the citizens and officials show more wholehearted interest in this necessary portion of municipal machinery, we shall continue to secure untrained and underpaid employees. As a result large investments are partly or wholly thrown away due to lack of proper operation.

Meaning of Good Operation.—Good sewage plant operation means the handling of the plant so that each unit performs its specific duty with the highest degree of efficiency. This can be accomplished only by constant and conscientious attention on the part of the operator. Let us consider, therefore, the nature of sewage, the usual processes of treatment, the purpose of each treatment unit and the means of obtaining or at least approaching the end desired.

In order to know the nature of the material to be handled, it might be best to stop for a moment to consider the composition of ordinary sewage. The sewage from a representative American city contains approximately the following constituents:

Solid matter, 200-800 parts per million	divided into	50% mineral of inoffensive material and 50% organic, that is, vegetable and animal matter which is offensive	25% of this is in suspension and 75% in solution whereas 40% of the offensive matter is in suspension and 60% in solution

The mineral matter such as clay and sand is of the least importance, except that it increases the bulk of solids to be handled.

The organic matter is of utmost importance, in fact, the whole sewage treatment operation is devised to arrange for its disposal in the least offensive and most economical manner. Organic matter always contains certain chemical elements (carbon, hydrogen and nitrogen) which change by the process known as decomposition. Decomposition is usually divided into two stages, putrefaction and oxidation.

Bacteria.—In the treatment of sewage these changes usually take place in the presence and through the action of very minute living organisms, so small that they cannot be seen with the naked eye. These organisms are known as bacteria. Roughly speaking, it would take from 5,000 to 20,000 bacteria, placed side by side to make a line 1 in. long. It is these organisms which use the organic matter contained in sewage as their food and in this way break down the complex compounds into simpler and less harmful products.

The air we breathe plays an important part in sewage treatment because it contains oxygen. Whenever oxygen combines with another substance we call the process "oxidation." This process occurs at sewage plants in the trickling filters, contact beds and sand beds. As a definite quantity of the organic matter in sewage requires sufficient oxygen to change it to a stable form, that is, a condition where there will be no further need for oxygen, the efficiency of these devices is measured by the degree to which this matter has been oxidized. As oxygen dissolves in water, it is this dissolved oxygen that is used in the oxidation of sewage.

Putrefaction.—When oxygen is removed from a substance, we call the process reduction. When this process continues far enough to remove all the oxygen present in sewage and no more is supplied, the remaining undecomposed matter will putrefy, that is, develop disagreeable odors.

These two references to chemical reactions are given here only to provide a better understanding of what is to follow and to indicate that there are certain tests available to the chemist, which enables him to determine how his plant is working.

Usual Sewage Treatment Processes.—We are now ready to consider the usual processes of sewage treatment. The first step usually is to remove the very large particles by screens. Then it is passed through tanks to settle out as much as possible of the suspended solids. Where the sewage includes storm water, grit chambers are used to remove the heavier mineral matter. From the tanks, the sewage passes through some type of control apparatus to the filter or oxidizing beds. From here it is not common to resettle the sewage or to treat it with a disinfectant to kill the harmful bacteria. When the activated sludge process is used presedimentation may or may not be used, but the oxidizing beds are omitted.

Screens.—Screening of sewage is accomplished by coarse and fine screens. The former are usually stationary, whereas the latter may be movable or fixed. The object of screening is to remove much floating and suspended matter as would tend to clog the pumping machinery, filter nozzles or any other portion of the sewage plant or to prevent the discharge of unsightly material into the receiving body of water if fairly complete treatment is not given to the sewage.

Operation of Screens.—Screens should be inspected daily to see that they are doing the work expected of them. Fine screens are usually self-cleansing, but the coarse fixed screen must be cleaned by hand. It is well to do this each day, even though the deposit may be small. Care should be taken to prevent pushing some of the larger particles, such as rags, through the openings, as this material may cause difficulties in other portions of the plant. If large quantities of material accumulate, the organic matter held back will soon start to decompose and produce objectionable odors.

The manner of disposing of screenings depends largely upon local conditions, primarily the size of the plant. Burning or burying is usually resorted to. When buried, at least 4 in. of earth cover should be provided.

Grit Chambers.—When sewage contains considerable sand, clay, or similar matter, a grit chamber should follow the screens. This is ordinarily the case when the storm water and household wastes enter the same sewer system. The only function of this structure is to reduce the rate of flow of the sewage to such a point that sand, gravel and other mineral substances will settle out and lighter organic solids will remain in suspension (velocity about 1 ft. per second.)

These chambers should be cleaned after every large storm and in dry weather when the deposited material is sufficient to increase the rate of flow through them to such an extent as to reduce their settling efficiency. If properly designed and operated the deposit should contain little organic mat-

ter. This means it is non-putrescible and inoffensive and can be used for fill, road building, etc.

Like all mechanical equipment the valves and sluice gates of the grit chamber should be examined and oiled at regular intervals to insure ready operation.

Tanks.—Following preliminary treatment, the sewage is subjected to a settling process on one or more types of tanks. The most common forms are the plain settling, septic and Imhoff tanks.

Each of these tanks have one purpose in common, the removal of the solid particles carried in suspension. This is the only function of the plain settling tank. As some of the particles are heavier and some lighter than water, it is evident that by reducing the velocity of flow the lighter particles come to the top and the others sink to the bottom.

In operation these tanks require constant attention. The floating material should be skimmed off at least daily, either by hand or by some mechanical device. The skimmings are usually buried. The time for drawing sludge depends upon the individual tanks. This can be determined by physical and chemical tests, by sounding the sludge depth, or by watching the effluent. The sludge should not be allowed to accumulate so as to reduce materially the active settling portion of the tank and thus increasing the velocity and increasing the solids carried off in the effluent.

The sludge from these tanks should be placed in other tanks known as digestion tanks.

A septic tank is a continuous flow sedimentation tank, which, in addition to removing suspended matter, reduces the volume and weight of the deposited sludge by bacterial action.

When the accumulation of scum or deposited sludge becomes so large that the working area of the tank is materially decreased or the effluent carries an excessive amount of suspended matter, the scum must be removed and the digested part of the sludge placed on drying beds. Either one or both of these operations may be performed at the same time. If more than one septic tank is available, it is good practice to allow the one from which sludge is to be withdrawn to remain idle for a few weeks to permit more complete digestion of the sludge.

Imhoff Tanks.—An Imhoff Tank is a structure which has two stories. In the top, the suspended solids are removed by settling, whereas in the bottom these solids undergo the process known as digestion.

Broadly speaking, digestion is a process by which the organic portion of the sludge is liquefied, gasified and mineralized.

Imhoff Tanks probably are used more extensively at small municipal and institutional installations than any other type of tank. Constant attention is essential. The inlet and outlet channels must be kept clean at all times. All material floating on the sedimentation chamber should be skimmed off daily or oftener, if necessary. The skimmer, as well as a number of other devises referred to in this paper, can be constructed along the lines illustrated in Catalog No. 31 of the Pacific Flush-Tank Co. The walls and sloping bottoms should be cleaned with a squeegee at least twice a week. Care should be taken not to stir the tank contents too much. In reversible tanks the flow should be reversed about every two weeks to insure even deposits of sludge. The slots at the bottom of the sedimentation chamber should be kept open.

The scum in the gas vents should be kept broken up by churning or by means of a water jet so as to allow the escape of gas. Sometimes this scum accumulates to such a depth that it cannot be kept in a semi-liquid condition and must be removed. Foaming occurs at times. The best remedy for this is not known to the writer. Various methods, such as spring with water, drawing sludge frequently in small amounts, and the application of liquid chlorine have been tried with varying degrees of success.

Sludge should never be allowed to accumulate in the digestion chamber so that it is nearer than 2 ft. from the slot at the bottom of the sedimentation chamber. This can be determined by soundings at regular intervals, preferably at least once a month during the open season. The writer has found a weighted circular plate 12 in. in diameter, attached to a wire to be the best sounder. Others prefer sampling with bottles lowered to various depths. This is usually done by attaching the bottle to a pole, lowering it to the desired depth, pulling the stopper with a cord previously attached and finally withdrawing the bottle more or less filled with sludge.

Well ripened sludge should be drawn off into sludge drying beds at intervals varying with different plants. In this state once a month probably is a fair average time interval for the period from April 1 to December 1. Never remove all the well digested sludge. At times, when foaming occurs in the gas vents and gassing brings considerable sludge to the surface of the sedimentation chamber, sludge must be drawn regardless of its condition.

Well digested sludge is almost black in color and has a tarry odor. Undigested sludge is grayish in color, sticky, does not dry well and has an offensive odor.

At many plants it has been a difficult problem to obtain well digested sludge. Several years ago the speaker determined some ratios of the rate and degree of digestion to the amount of seeding material used. It was learned then that the degree of alkalinity or acidity of the sludge had a bearing upon the speed and degree of digestion. Within the past few years, it has been found that the application of lime to sludge and scum to obtain a pH value between 7.3 and 7.6 will produce the best and most rapid digestion of sludge.

The pT scale can be likened to the thermometer scale. On this scale 32° represents the freezing point of water. Any values higher than 32° denotes an increase in heat whereas any values below 32° denote an increase in coldness. In other words, the degree of heat increases as the numbers increase and the degree of coldness increases as the numbers decrease. In like manner the degree of alkalinity or acidity of a solution is expressed by the Hydrogen Iron Scale where we use pH values instead of degrees. At pH 7.0 we have a neutral solution. With a decrease in these figures the acidity of the substance being tested increases whereas with an increase in numbers we have an increase in alkalinity. In other words, if we have a pH of 6.8 we need lime to obtain a pH of 7.3 to 7.6, but not as much as would be needed if the pH were 6.0. The best method or place of applying the lime in actual practice is open for discussion.

Digestion tanks are separate tanks into which plain sedimentation tank or undigested sludge is placed for digestion. The temperature of the sludge in separate digestion tanks or in the sludge chamber of Imhoff Tanks, has a material bearing upon the digestion process taking place therein. A uniform temperature of about 70° F. is beneficial.

Dosing or Control Devices.—Dosing devices are used to control the application of settled sewage to the oxidizing units. At large plants various controls may be employed, but at small plants the automatic sewage siphon usually is used. Only liquid should enter the dosing chamber. This should be drained occasionally and the sides and bottom cleaned, as an excessive accumulation of solids may interfere with the operation of the siphon.

The failure of sewage siphons to operate properly is usually due to one of two causes, namely, an air leak in the bell or some part of the piping connected to the bell, or the clogging of the apparatus.

Oxidizing Device.—The usual oxidizing devices at sewages plants are trickling filters, contact beds and sand filters. The primary object of these units is to add sufficient oxygen to the settled sewage to make it stable, that is, to prevent odor production and to reduce the oxygen demand of this liquid. By accomplishing the latter the production of a nuisance in the body of water into which the sewage plant effluent will discharge may be avoided.

The operation of each of these types of oxidizing devices is somewhat different, but to accomplish their ultimate object, certain attention is required. It is possible of course, to determine their efficiency by chemical tests, to be illustrated this afternoon, but my only purpose here to is to indicate the regular attention these units require.

Trickling Filter.—Although automatic in action the trickling filter needs regular attention. To obtain maximum efficiency of these beds the sewage should be distributed evenly. This means that the nozzles and rinser pipes must be kept clean and free from deposits and growths.

Occasionally pooling occurs on these beds. This usually is due to a greenish growth common to these filters. Pooling should be prevented by keeping the surface of the beds clear of grass, weeds and this green growth. The latter can be removed by flushing with a hose, turning the surface over with forks or rakes, or where possible, by allowing the bed to remain idle for from 24 to 48 hours and then turning on the sewage. By the latter method the dried film washes away easily, but this procedure may

produce objectionable odors. It is claimed that the application of copper sulphate or liquid chlorine will remedy this condition.

During the winter it becomes necessary at some plants to remove the nozzles entirely to avoid freezing. Although this procedure must be followed the nozzles should be replaced as early in the spring as weather conditions will permit.

A disagreeable feature of trickling filters is the breeding of a small moth fly in the top few inches of the stone bed. This can be controlled by flooding the bed. Recently it has been claimed that the breeding of these flies can be controlled also by applying the liquid chlorine every fourteen days to the sewage being sprayed on the bed.

Contact Beds.—The number of contact beds in active use in Maryland is small. It may be well, therefore, to state that, while trickling filters and contact beds are built of stone, the real difference in them lies in the method of operation. With trickling filters the sewage is applied continuously and evenly, whereas for contact beds the sewage is applied, then allowed to remain in the bed for some time and then after emptying, the bed is allowed to remain idle. A representative cycle for contact beds is: one hour filling, two hours standing full, fifteen minutes emptying and approximately four hours resting. The most important feature of operation is to see that the best cycle is determined and then maintained and that the beds are given a complete rest of two days every six or eight weeks.

Sand Filters.—In the operation of sand beds sewage is applied intermittently to the surface of the bed, sufficient time being allowed between doses to let the bed return to its best operating condition by reason of the oxygen drawn into the bed as the sewage seeps through.

In caring for these beds it is always necessary to see that the beds are not dosed too frequently. After once determining the best period between doses, probably not less than 6 hours, this rate should be maintained. When a mat forms on the bed so that the sewage cannot pass through freely this should be removed. Although it sometimes becomes necessary to loosen up several inches of the sand to get good operation the sand should never be turned over without first cleaning off all deposits. Always keep the beds as level as possible and apply the sewage uniformly, giving careful attention to the distributor system. No growth of grass or weeds should be allowed on the beds and heavy wagons should be kept off of them. Repair all wash-ins and broken ventilators at once. Never allow the application of sewage in such a way that it will find its way through holes directly to the underdrains.

Winter operation of sand beds is important. In the late fall the beds should be placed in first class condition. The sand should be ridged and furrowed or placed in piles so that when the first dose of sewage is applied to the bed, the surface of the liquid will freeze and the rest of the liquid will pass through the sand, the sheet of ice being supported by the ridges of piles. Advantage should be taken of the warm days to remove the sludge mat, if necessary. Early in the spring the surface of the sand should be cleaned, the sand loosened and the beds leveled.

Activated Sludge Treatment.—There is a system of oxidizing sewage without applying it to contact beds, trickling filters or sand filters. This process is known as "Activated Sludge" treatment. Sludge in a brown, flocculent condition is thoroughly mixed with the raw sewage by means of compressed air. By this thorough mixing and addition of air the solids in the raw sewage are so changed that they will settle in a second tank and the tank effluent will approach stability.

Much could be said about this method of sewage treatment, but it is enough to state here that this type of plant requires very careful attention. Among the items to be looked after are the mixture of a proper amount of activated sludge with the raw sewage, the adjustment of the proper amount of air added, the cleaning of the settling tanks when needed and numerous problems involved in the handling and disposal of sludge.

Disinfection.—It frequently happens that it is necessary to disinfect a sewage plant effluent to protect a water-course which may be used later as a water supply, by cattle or for shell-fish growing. Perhaps the most effective and economical method of disinfection, or at any rate, the one most in use, is the application of liquid chlorine. A number of details must be cared for on liquid chlorine machines. It is well to mention, however, that a method of determining whether or not sufficient chlorine is being added should be used by all operators. This is a simple test for what is called "residual chlorine." This test was demonstrated yesterday afternoon. Remember to apply an ample amount of chlorine, however, so that the residual chlorine is equal to at least 0.5 p.p.m. after ten minutes contact.

Sludge Treatment and Disposal.—The disposal of the solids removed from sewage by settling, commonly known as sludge, presents a very difficult problem. In the fresh condition it is very offensive. It is usually changed from this condition to an inoffensive or digested condition in the sludge compartment of an Imhoff Tank or in separate sludge digestion tanks. After digestion it is ordinarily applied to sand beds for drying, but at some of the larger plants, filter presses and centrifuges have been used.

For sand bed drying the most efficient operation is obtained by applying the sludge to the beds to a depth not greater than 12 in., but preferably not more than 8 in. The sludge should be thoroughly dried and removed before applying more sludge to the sand bed. Never dig holes through the bed to make the sludge drain more freely, as this leads to dirty sand and not infrequently to clogged underdrains. The addition of aluminum sulphate and to the sludge as it is placed on the bed hastens drying. Do not send undigested sludge to the drying beds if this can be avoided. Prevent contact between sludge and sand or earth embankments at the edge of the sludge layer, as flies breed in earth or sand saturated with sludge liquor.

Miscellaneous.—It is well to have water supplied under suitable pressure at every plant. This helps in breaking up the scum in the gas vents of Imhoff tanks, the removal of the growth on the trickling filters and in keeping the plant generally tidy.

Sewage should never be by-passed around any unit of the plant, except in extreme emergency. If done, a complete record of the time and reason for by-passing should be kept.

Operation Records.—A record of the plant operation should always be kept. Such records will give more intimate knowledge of what the plant is doing. When no laboratory facilities are provided, considerable knowledge of the manner in which the small plant is operating can be obtained by the use of Imhoff cones for estimating the settling efficiency of the tanks, and by the methylene blue test for the determination of the stability of a trickling filter, contact bed or sand bed effluent.

Summary.—To summarize briefly, it has been pointed out that:

1. Sewage treatments plants are constructed for the purpose of changing the organic content of sewage to an inoffensive condition as rapidly as possible, with a minimum of odor and other nuisances, and to prevent pollution of the water-courses into which the treated sewages are discharged.
2. The citizen, official, designing engineer and operator all have a joint responsibility in bringing about successful operation of a sewage treatment plant. The citizen must show more interest, the official must pay better salaries for the more or less disagreeable duties performed by the operator, the designing engineer must not design and forget, but rather keep in touch with the operator to act in an advisory capacity and the operator must be thoroughly and intelligently interested in his work.
3. The operator must realize that he is in charge of an important factory whose processes he must understand. It may produce nothing marketable, but only by proper management will the sewage plant produce a satisfactory effluent and eliminate or reduce the odors at the plant to a minimum.
4. The plant should receive careful, daily attention.
5. No plant is automatic and it will not operate, therefore, without regular attentions. Definite operations, for example, as squeegeeing the sloping walls of the Imhoff tanks, must be performed at definite intervals. Until such regular attention is given to the sewage plant operating difficulties will not be reduced to a minimum.
6. Daily records are essential for best operation.
7. Where no laboratory is available the Imhoff cone test is recommended for a test of the settling efficiency of the tanks and the methylene blue test for the effect of the oxidizing device upon the treated sewage.
8. Where sludge is adjusted by the use of lime to obtain better digestion, the colorimeter pH test is valuable.
9. Whenever disinfection by the use of liquid chlorine is used the test for residual chlorine is essential.

Who Pays for Sewer Taps?

The following was taken from *Water Works:*

Municipal work of all kinds in the State of New York is greatly simplified by means of a coordinating bureau that furnishes information for the guidance of the municipalities of the state. This bureau, the New York State Bureau of Municipal Information, City Hall, Albany, N. Y., headed by W. P. Capes, director, and officered by mayors of various cities and towns in the state, makes a business of assembling and tabulating information on methods ruling municipal work in cities, towns, and villages, and places such information at the disposal of the communities of the state in order that they may be kept up to date on the best methods that may be developed.

Who Pays?—An interesting survey recently completed by the bureau tabulates matters relating to Sewer Taps. The first point displayed by the report is that out of 74 communities listed, 65 require the property owner to pay for sewer taps, 8 stand the cost out of municipal funds, and one, Binghamton, assesses property at $1.00 a foot (50 cents for corner lots) on new sewer work, this assessment giving the owner a connection to the curb line. In this city, if the owner wants a new connection the city carries it to the curb line by city forces and charges for actual labor and material. Another city, included in the 59, not only compells the property owner to defray the cost of the tap, but also charges him the cost of making the cut in the street and of repairing the pavement. The communities making no charge are Corning, Geneva, Hempstead, Johnstown, Lancaster, Middletown, and Watervliet. These latter towns all have a population of under 20,000.

Who Does the Work?—The second question in the survey shows by whom the actual work of connection is done. In fifteen of the communities listed the work of making the connection is done by city forces or by the city under contract. The following tabulation answers the question, "Does the Municipality Do This Work?"

Auburn—In new sewers municipality constructs laterals from main line sewer to city curb. Property owners construct lateral from curb to house. Existing street sewers property owners pay entire cost for house connection and arrange for work to be done. Where new sanitary street sewers are constructed and house connections built to curb line, abutting property owner pay entire cost. The work is done by municipality under contract. Where excavations are made by property owner, city requires the property owner to pay the cost and usually arranges for the work to be done.

Albany—No. The office of the Commissioner of Public Works issues permits free of charge to tap in the sewers. The property owner supervises this work and it is done by plumbing contract.

Albion—No.
Beacon—Plumbers' work.
Batavia—No.
Buffalo—No.
Corning—No.
Cohoes—No.
Cortland—No.
Catskill—Yes.
Dunkirk—No.
East Rochester—Yes.

Elmira—No. City bears the entire cost of trunk line and lateral sewers. It provides "Y" branches for the different property owners, locates such branches when owners wish to connect, makes inspections of such locations but pays for none of the service work.

Fredonia—No. Done by licensed plumbers.

Fulton—No. done by licensed plumbers. If sewer is put in after street is paved, property owner is required to pay, in addition to sewer connection, for repaving the street.

Glens Falls—Yes, from main to curb.
Gloversville—No, done by licensed plumbers.
Geneva—Yes, tap and lay first pipe.
Hempstead—Yes.
Hornell—No.
Hudson—No, done by property owners.
Hudson Falls—No.

Ithaca—No. done by licensed and bonded sewer layer. Inspected by city.

Johnstown—Yes.
Jamestown—Yes.
Kenmore—No. Owner has to pay for opening streets.
Kingston—No.
Little Falls—No.
Long Beach—Yes.
Lackawanna—No.
Lynbrook—No.
Lancaster—No, but city inspects.

Medina—No, but all connections are made under supervision of street superintendent. Whenever permanent pavement is constructed on streets all property owners are notified to make necessary sewer connections.

Mount Vernon—When sewers are laid spurs or "Y" connections are placed at points approximately 25 feet apart, allowing one for each 25 feet on each side of sewer. Cost of this work is assessed against abutting property owners. When the owner is ready to make the connections with the sewer his plumber applies for the permit. This permit costs $5.00 plus the flat rate for opening the pavement. The price of the pavement depends on the type in use.

Mamaroneck—Property owner under supervision of engineers.

Middletown—No.
Malone—No.
Newark—Yes.

Norwich—No. The licensed plumber makes the connection. The city reserves the right to restore all street openings and charge the cost thereof the person to whom the permit is issued.

Newburgh—The municipality does not make flat work connections. The property owner has this work done by his plumber who files a bond with the city to indemnify the city against any loss by reason of the opening of the street in the making of this sewer connection. The only charge by the municipality is where the street has a macadam or paved service. The city does this work and renders a statement of the cost to the property owner which he must pay.

Niagara Falls—No.
New Rochelle—Plumber.

New York City—Owner lays house connection into spur. City only inspects the work.

North Tonawanda—No, done by licensed plumber.

Oneida—No, done by licensed plumber. City lays sewer from main to curb besides tapping main sewer.

Oswego—Yes.

Plattsburgh—Owner does the work and city makes the connections on main sewers.

Penn Yan—City makes tap and supervises other work.
Port Chester—Only when owner fails to do it.
Peekskill—No.
Poughkeepsie—No.
Port Jervis—No, supervises only.
Rome—No, supervises only.

Rochester—No. When sewers are laid laterals are run to lot line to which property owner connects.

Rye—Yes.

Saranac Lake—Village makes the tap and consumer furnishes the material and opens and fills trench. Village lays service pipe from main to curb.

Salamanca—No, city supervises.

Schenectady—Yes, under contract between main and curb. Between curb and house it is installed by plumber engaged by owner.

Sherrill—No.
Syracuse—No.
Scotio—No.
Saratoga—No.
Scarsdale—No.
Seneca Falls—No.
Tonawanda—No.
Tarrytown—No.

Utica—When not done in advance of paving work, city does the work. On paved streets, property owner also pays for restoration of pavement.

Watertown—Yes.
Watervliet—No.
Yonkers—No.

What Charges Are Made?—Another question, relating to the amount charged property owners for the work of making sewer taps and connections, revealed a lack of uniform-

ity in the rates charged and in the method of computing charges. The answers to this question follow:

Binghamton—In replacement of road surfaces city charges owners for labor and material if they desire a connection in a location other than where the original was located.

Beacon—$1.50.

Buffalo—The paving contractor is responsible for the construction of necessary lateral sewer and water connections. These connections are constructed under the supervision and in accordance with directions from the city engineer, the unit rates for same being a part of the contract, but being a special assessment against the property benefited.

Catskill—Labor and materials.

Corning—Property owners pays for relaying of pavement. Plumbers are licensed and bonded and compelled to take out permits to open the streets.

Cortland—None.

Cohoes—$4.40 per square yard for restoring pavement.

East Rochester—Labor and material at cost.

Glen Falls—Dirt streets $17.00; macadam $20.00; paved $42.00.

Jamestown—Actual cost for work and materials up to $25.00.

Kenmore—In dirt or cinder streets 60 cts.; asphalt or brick $20.00; cement $15.00; macadam $5.00; inside of curb, 60 cts.

Long Beach—An average of $15.00 is charged before the pavement is laid. If payment is laid and permit issued to dig up street, the average is $45.00.

Malone—This village has a peculiar situation in that the sewers are not under the supervision of the village, but are owned and maintained by sewer companies or associations, as they were before the village was incorporated, and only give permits allowing work in the streets to be done on them without the actual supervision.

Mamaroneck—Earth or macadam street, $4.00 fee and $25.00 deposit. Paved streets, $4.00 fee and $100.00 deposit.

Newark—Cost plus ten per cent.

New Rochelle—Dirt streets, $7.50; macadamized streets $15.00; penetration macadam streets, $30.00; asphalt and other paved streets, $40.00.

New York City—A charge of $10.00 is made for privilege of connecting to sewer in the Borough of Manhattan. The charge is made for the cost of issuing permit and for cost of restoring pavement if street has been paved. $1.00 is charged for permit and a deposit of $10.00 for 12 square yards, one-half for first restoration and other half for possible second restoration if settlement occurs, actual cost of labor and materials being charged and refund of balance, if any, being made. No charge for opening unpaved streets except for permit.

Ogdensburg—$5.00 is charged. Property owner stands the expense of excavation and back-filling. On paved streets sewers are laid as far as curb before paving.

Oswego—Cost of tile and labor.

Plattsburgh—For earth streets, $5.00; for macadam, $10.00; for paved streets, $25.00.

Penn Yan—$1.00 for tap. Property owner pays all other expenses.

Port Chester—Actual cost.

Rochester—Charge for actual time of inspector on job. If pavement is cut, property owner pays for repairs which are made by city.

Rye—About $1.75 where there is no rock.

Scarsdale—$25.00 for street opening deposit. Repairs made by village and deduction of cost of restoring highway made from deposit.

Sherrill—Property owner pays for sewer when it is laid. He makes tap at his own expense.

Tarrytown—Village makes a charge for street opening based on size and kind of pavement removed. Charges are as follows: Dirt streets, 5 cts. per square foot; macadam streets, 10 cts. per square foot; brick and bituminous macadam, 30 cts. per square foot; concrete and other types at cost.

Utica—Cost varies with depth of sewer and length of line, varying from $55.00 to $90.00.

Watertown—Actual cost plus road cut. Road cuts are as follows: Earth, 50 cts. per square yard; macadam, $2.50 to $3.00 per square yard; pavement, $5.00 per square yard.

Watervliet—$15.00 for dirt, gravel or macadam streets; $20.00 for granite block or other stone surface street without concrete base; $25.00 in concrete, granite block or concrete base or other kindred pavement.

Yonkers—$5.00 per each connected.

Meterage

Setting Meters

The following was taken from a booklet issued by the Buffalo Meter Co.:

Size of Meters.—More than 90 per cent of the service pipes of most water works are ½ in. or ¾ in. and can be metered with ⅝ in. meters. This size is certainly large enough for premises occupied by the average family. Two family flats having a single ¾ inch. or larger service pipe are usually supplied through a ¾ in. meter.

When the meter selected is too large it has several disadvantages; the greatest possible sensitiveness to small leak flows will not be obtained, the first cost of metering the service will be unnecessarily high and the minimum charge for water high if based as usual on the size of the meter. When the meter selected is too small, there will be complaints of lack of pressure and no water, and the overworked meter will be expensive to maintain. Where the minimum charge for water is based on the size of the meter consumers often apply for meters that are too small.

Location of the Meter.—Four different methods are in general use for installing water meters: First, in the cellar; second, buried in the lawn with dial extension; third, in a vault built in the lawn; fourth, in a meter box buried in the lawn. Some water works officials advocate that particular method which they have adopted, to the exclusion of all others, but each method has some advantages all its own and the best one to employ depends upon the service conditions to be met.

Cellar Setting.—Undoubtedly the great majority of meters are set in cellars. In the business districts of cities, frequently no other location is available as there are no lawns and no earth beneath the sidewalks. This is the least expensive plan for setting meters and it also permits of the consumer reading the meter himself which should certainly be his privilege. The atmosphere in cellars is generally dryer than in out-door vaults and boxes so the registering parts of meters are not so liable to corrode and stick. Heavy snow falls do not prevent reading the meters. The meter should be set horizontally and close to the stop and waste cock so no connection can be made subsequently to the pipe between the meter and the water mains without being detected. Some water works protect cellar meters with a cast iron lock box or with a wooden box having a hinged lid and padlock—such protection is not usually considered necessary.

Buried with Dial Extension.—If a premises has no cellar or there is a hydrant in the front yard the meter must then be set between the street curb and the property line. The meter is set in the direct run of the service pipe and buried; its dial is elevated to the surface of the ground and protected by a cast iron curb box. Many meters are set in this manner and it is the least expensive form of out-door installation; the meter dial is in the most accessible location for reading without disturbing the consumer; sealing is not usual as there is no chance for tampering; leaks on the service pipe between the meter and the house will be registered; there is less liability of damage from hot water forced or drawn back through the meter and no damage from freezing if the service pipe is below frost line; the meter register is in a position accessible for repairing but if the submerged works of the meter require repairs the meter must be dug up.

Vault Setting.—Another style of outdoor setting consists of a vault extending from the surface of the ground down to the service pipe and covered by a cast iron cap. The walls of the vault may be built of concrete, brick, vitrified sewer tile and even wood. Some water works officials advocate setting the meters in the direct run of the pipe at the bottom of the vault and others prefer elevating the meters about midway by risers; when the latter method is employed keep the meter in the center of the vault and the pipes 4 or 5 in. from the walls of the vault to reduce liability of freezing. If vaults are liable to be flooded by surface water a drain should be constructed to the sewer or the meter dial elevated above high water mark by an extension. Vault settings have many of the advantages mentioned above with dial extension settings and besides provide for quickest removal of the entire meter for repairs.

Meter Box Setting.—There is a variety of cast iron boxes made for protecting meters set out-doors. The construction of these boxes depends upon the climatic conditions under which they are to be used and the ideas of the various manufacturers. The simplest and least expensive consist of an oval, cone-shaped cylinder with the lower end open and the surface end with a cover and lock bolt; this style is generally made 1½ ft. or 2 ft. long for use in warm climates where the pipes are not buried deeply. The meter is set at the bottom of the box in the direct run of the pipe. Other boxes for cold climates are adjustable for pipes buried at different depths; some are water tight and some have special connections for the quick exchange of meters.

Rules for Setting and Starting.—Before cutting the service pipe, flush it thoroughly to remove sediment, sand and gravel which are liable to make trouble if washed into the meter. After cutting and threading the pipe, remove thread-cutting chips from inside the end of the pipe.

If the service to be metered is new a temporary flushing pipe the length of the meter should be placed in the meter couplings and after a few days' use of water the flushing pipe removed and the meter installed.

Do not use paint or joint compound freely on the pipe joints between the meter and the mains as it is liable to wash into the meter and clog the working parts.

Keep the tin caps on the threaded spuds of the meter until the last thing before attaching to the pipes—then blow through the meter to be certain the mechanism is in operative condition.

Disc meters operate successfully in all positions but for best results set them level.

After the meter is set open a faucet and turn the water on slowly so it will gradually expel the air and fill the meter and pipe. Mixtures of air and water under full pressure resulting from not observing this rule are liable to strain and damage the meter's works.

Results of Meterage

Meters Decrease Pumpage and Increase Revenue at Cleburne, Tex.—How the installation of meters decreased the pumpage and increased the revenue at Cleburne, Tex., is well shown in the accompanying diagram from the October, 1925, issue of Water Works. In 1910 there were almost no meters in the system. By 1916 the number installed had

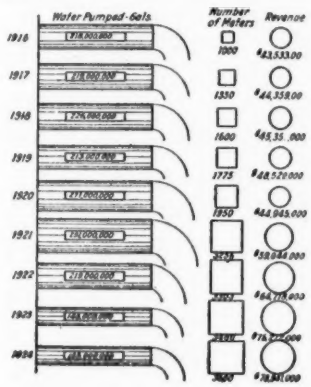


Diagram Showing Pumpage, Meters in Service and Water Revenue at Cleburne, Tex.

reached 1,000 and since had increased to 3,600 in 1924. During the period from 1916 to 1924, inclusive, there was a decrease of 28 per cent in volume of water pumped, and an increase of 81 per cent in revenue. According to the U. S. census Cleburne had a population of 10,304 in 1910 and 12,820 in 1920.

Meterage Reduces Water Consumption 75 Per Cent at Hegewisch.—One of the most remarkable instances of the reduction of water consumption as the result of the installation of meters took place at Hegewisch, a section of Chicago, Ill. According to the 1921 report of the Department of Public Works of Chicago, as noted in *Water Works* for

January, 1923, the installation of the meters brought about a reduction of domestic consumption from 433 gal. per capita to 75 gal. The meters were installed during 1920 on every service, about 850 in number, in the town. A test made on Jan. 31, 1920, showed the total average consumption in Hegewisch amounting to 2,730,000 gal. per day. On Nov. 10, 1920, when the meters were about one-half installed, the total average consumption was 1,640,000 gal. per day. During 1921 these meters were read on different occasions and efforts made to stop the waste and reduce the loss due to leaky plumbing and the use of hopper closets, resulting in further reduction in this section. Final test made on Oct. 20, 1921, indicated an average daily consumption of 620,000 gal. per day, which is less than 25 per cent of the original consumption.

Effect of Metering on Public Health.—One of the stock arguments of opponents of metering is that it will endanger the health of the community by curtailing the use of water for washing, bathing and all household purposes. This, of course, is untrue and cannot be substantiated from health

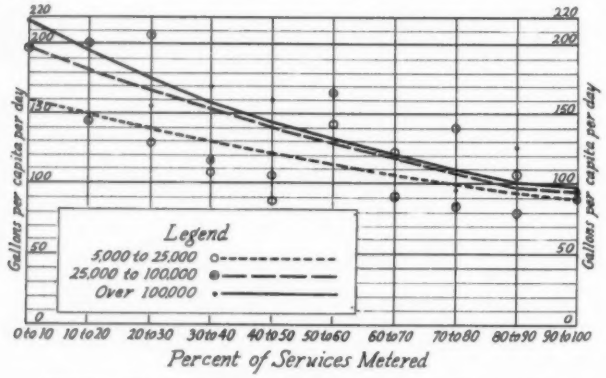

Gallons per capita per day
Legend
5,000 to 25,000
25,000 to 100,000
Over 100,000
0 to 10 10 to 20 20 to 30 30 to 40 40 to 50 50 to 60 60 to 70 70 to 80 80 to 90 90 to 100
Percent of Services Metered

Diagram Showing Effect of Meters on Water Consumption

statistics in any community where general metering has taken place. In 23 cities in the United States ranging in size from 263,500 to 2,859,925, Seattle with a 99 per cent metered service had the lowest death rate (9 per 1,000 inhabitants), while Milwaukee, 100 per cent metered, was the second lowest with 9.8 per 1,000. In Detroit there has been a constantly decreasing death rate with an increasing installation of meters. From the years 1901 to 1911 with 9.1 per cent of the services metered the per capita consumption in Detroit was 138 gal. From 1919 to 1924 with 98 per cent metered the average use was 116 gal. per capita, a reduction or saving in pumpage of 16 per cent.

Data on Metering from 510 Cities.—In a report presented in 1925 to the Commissioner of Public Works of Chicago, Ill. (See Water Works, August, 1925), Maury & Gordon, Consulting Engineers, gave the following table and diagram showing the effect of meters on water consumption:

Effect of Meters on Water Consumption

Percent of Services Metered	Cities 5,000 to 25,000 Population Number of Cities	Gal. per Capita per Day	Cities 25,000 to 100,000 Population Number of Cities	Gal. per Capita per Day	Cities 100,000 Population and Over Number of Cities	Gal. per Capita per Day
0 to 10	60	160.8	16	197.5	3	217.6
10 to 20	20	199.4	3	143.6	3	148.6
20 to 30	17	128.5	2	208.0	3	154.3
30 to 40	15	107.7	4	115.5	3	170.0
40 to 50	8	88.4	5	104.8	3	160.3
50 to 60	18	140.8	5	165.2	0	0.0
60 to 70	18	119.8	4	90.7	0	0.0
70 to 80	16	139.8	10	84.4	4	96.8
80 to 90	31	79.1	9	106.6	10	126.8
90 to 100	145	90.9	53	93.5	22	97.0
Total	348		111		51	

The curves in the diagram represent the average results in 510 cities in the country. The solid black curve shows the average pumpage in cities of over 100,000 population, having various percentages of their services metered. It will be seen that the average pumpage in cities having from 10 to 20 per cent of their services metered is 195 gal. per capita per day. The curve further shows that in large cities having from 90 to 100 per cent of their services metered, the daily per capita pumpage is only 97 gal.

Meterage Results in 150 Ohio Cities and Villages.—A study of meter installations and rates in 150 cities and villages by the State Department of Health of Ohio (See Water Works, December, 1923) showed that for cities and villages with services 100 per cent metered the average daily consumption was 90 gal. per capita and for cities and villages with no metered service the average daily consumption was 170 gal. per capita.

Meter Rates

Some interesting information on meter rates in large cities has been obtained recently by the Municipal Reference Division of the Seattle Public Library at the request of the Water Department of Seattle, Wash. Letters were sent to the Water Departments of the 34 cities of over 200,000 population. Through the courtesy of the Municipal Research Division we are able to print below the results of their investigation:

Eight of the 34 departments did not reply. The latest information available for these cities is included for the sake of completeness, with authority given in each case. Very often the only information available was that given in a similar compilation made by the Seattle Public Library in 1924. "1924 information" refers to the former report.

The population figures are U. S. Census Bureau estimates of 1927 unless otherwise stated.

The percentage of metered sources is taken in most cases from a table compiled by the Chicago City Engineer in 1925 and printed in the recent report of the Chicago Department of Public Works on water waste.

Newark has been omitted as no information concerning that city is available.

Akron, O.—(208,435) 1920 census, no cost. 100 per cent metered. First 20,000 cu. ft. per quarter, $1.60 per 1,000; next 20,000 $1.50 per 1,000; next 20,000, $1.40 per 1,000; next 20,000, $1.30 per 1,000; over 80,000 cu. ft., $1.20 per 1,000. Minimum monthly rates: ⅝ in. meter, $1.20 per mo.; ¾ in., $2.00; 1 in., $3.00; 1½ in., $4.00; 2 in., $5.00; 3 in., $7.00; 4 in., $10.00; 6 in., $15.00; 8 in., $25.00; 10 in., $40.00.

Atlanta, Ga.—(249,000). Maximum rate 20 ct. per 100 cu. ft.; minimum rate, 10½ ct. per 100 cu. ft. Minimum charge per mo., $1.00 for 500 cu. ft. 1924 rate, no later information received.

Baltimore, Md.—(819,000). 18 per cent metered. First 5,000 cu. ft. per quarter, $2.00 per 1,000; next 45,000, $1.00 per 1,000; over 50,000, 75 ct. per 1,000.

(Minimum Quarterly Rates)

⅝	in. meter,	$ 2.00	for 1,000	cu. ft.
¾	in. meter,	3.50	for 1,750	cu. ft.
1	in. meter,	6.00	for 3,000	cu. ft.
1½	in. meter,	10.00	for 5,000	cu. ft.
2	in. meter,	15.00	for 10,000	cu. ft.
3	in. meter,	30.00	for 25,000	cu. ft.
4	in. meter,	50.00	for 45,000	cu. ft.
6	in. meter,	90.00	for 96,667	cu. ft.
8	in. meter,	160.00	for 190,000	cu. ft.
10	in. meter,	225.00	for 276,667	cu. ft.
12	in. meter,	275.00	for 343,333	cu. ft.

Charitable rates: 9 ct. per 1,000 cu. ft. to organizations giving treatment to over two-thirds of inmates; 12 ct. of free treatment to one-third to two-thirds of inmates; 14 ct. of free treatment to less than one-third of inmates; 39c if no free treatment.

Religious rates: 39 ct. per 1,000 ft.

Educational rates: 48 ct. per 1,000 cu. ft.

Boston, Mass.—(793,100). 94 per cent metered. First 20,000 cu. ft. per year, $1.54 per 1,000; next 20,000, $1.43 per 1,000; next 960,000, $1.32 per 1,000; over 1,000,000 cu. ft., per year $0.88 per 1,000. Minimum charge, $8.80 per year.

Chicago, Ill.—(3,102,000). Meter may be installed on request. 60 ct. per 1,000 cu. ft. 15 per cent discount if paid within 30 days. Information J. Chicago City Council 26 Jan. 1927, p. 5353.

Buffalo, N. Y.—(500,000). First 3,000 cu. ft. per mo., $1.00 per 1,000; next 3,000, 70c per 1,000; over 6,000, 40 ct. per 1,000. Minimum meter rate as follows:

Size of meter	Rate per year	Water allowance cu ft.
⅝ in.	$ 12.00	12,000
¾ in.	15.00	15,000
1 in.	20.00	20,000
1½ in.	30.00	30,000
2 in.	40.00	41,714
3 in.	50.00	56,000
4 in.	100.00	169,000
6 in.	200.00	419,000
8 in.	300.00	669,000
10 in.	400.00	919,000
12 in.	500.00	1,169,000

1924 rate. No later information received.

Cincinnati, O.—(401,247.) 98.6 per cent metered. 12 ct. per 100 cu. ft. Minimum charge, 40 ct. per mo. Charitable rates: Free to the extent of 40 gal. per day per person to charitable institutions; half rates (same limit in amount) to institutions partly supported by fees; ¾ rate to churches, gymnasiums and other community welfare organizations.

Cleveland, O.—(972,600.) 100 per cent metered. 60 ct. per 1,000 cu. ft. Minimum semi-annual rates: ⅝ in. meter, $3.00; ¾ in., $7.50; 1 in., $9.00; 1½ in., $12.00; 2 in., $18.00; 3 in., $37.50; 4 in., $60.00; 6 in., $112.50; 8 in., $200.00.

Columbus, O.—(291,400.) 99 per cent metered. P. W. Je. 1926, p. 187. First 25,000 cu. ft. per mo. $1.20 per 1,000 25,000 to 200,000 cu. ft., per mo. $1.15 per 1,000; 200,000 to 2,000,000 cu. ft. per mo., $1.10 per 1,000; all over 2,000,000 60c per 1,000. Minimum charge, 40 ct. per mo. 1924 information with minimum rate as given in Public Works, June, 1926, p. 187.

Denver, Colo.—(289,800.) 2 per cent metered. 1,000 to 15,000 gal. per mo. 17 ct. per 1,000; 15,000 to 30,000, 16 ct. per 1,000; 30,000 to 60,000, 15 ct. per 1,000; 60,000 to 150,000, 13 ct. per 1,000; 150,000 to 315,000, 12 ct. per 1,000; 315,000 to 637,500, 11 ct. per 1,000; 637,000 to 20,000,000, 10 ct. per 1,000; over 20,000,000 gal. per mo., 8 ct. per 1,000. Minimum rate for residence, 25 ct. per month. Minimum rate for business premises, $3.00 per month. No residences are metered. Flat rate for 4-room house, $2.00 semi-annually with 40 ct. additional for every additional 2 rooms.

Detroit, Mich.—(1,334,500.) 99½ per cent metered. First 10,000 cu. ft. per quarter, 65 ct. per 1,000; next 90,000, 50 ct. per 1,000; over 100,000, 40 ct. per 1,000. Minimum charge, $1.25 per quarter. Service charge per year: ⅝ in. meter, $2.40; ¾ in., $3.60; 1 in., $7.20; 1½ in., $14.40; 2 in., $24.00; 3 in., $33.60; 4 in., $43.20; 6 in., $72.00; 8 in., $110.40; 10 in., $158.40; 12 in., $187.20; 16 in., $302.40; 24 in., $532.80.

Indianapolis, Ind.—(374,300.) 30 per cent metered. (Private company.) 1st 700 cu. ft. per mo., 21½ ct. per 100; next 11,300, 14 ct. per 100; next 18,000, 12 ct. per 100; next 20,000, 10 ct. per 100; next 50,000, 8 ct. per 100; next 100,000, 6 ct. per 100. Minimum monthly rates: ⅝ in. meter, $1.50; ¾ in., $4.50; 1½ in., $7.00; 2 in., $11.00; 3 in., $20.00; 4 in., $30.00; 6 in., $50.00. Information from Amer. City Jl. 1926, p. 111.

Jersey City, N. J.—(321,500.) 35 per cent metered. 90 ct. per 1,000 cu. ft. Information from Public Works, Sept. 1926, p. 303.

Kansas City, Mo.—(383,100.) 82.5 per cent metered. First 2,000 cu. ft. 17 ct. per 100; next 2,000, 16 ct. per 100; next 3,000, 15 ct. per 1,000; next 3,000, 14 ct. per 100; next 5,000, 13 ct. per 100; next 5,000, 12 ct. per 100; next 10,000, 11 ct. per 100; next 20,000, 10 ct. per 100; next 50,000, 8 ct. per 100; next 400,000, 7 ct. per 100; all over 500,000, 6 ct. per 100 cu. ft. Minimum charge 50 ct. per month.

Los Angeles, Calif.—(1,200,000, local estimate.) 99 per cent metered. 1st 10,000 cu. ft. per month, 13 ct. per 100; next 40,000, 11 ct. per 100; next 50,000, 9 ct. per 100; all over 100,000, 7 ct. per 100. Minimum charge per month, ⅝ in., ¾ in. or 1 in. meter, $1.00; 1½ in., $1.50; 2 in., $2.00; 3 in., $3.00; 4 in., $4.00; 6 in., $6.00.

Louisville, Ky.—(320,000.) 353 gal. daily or less, 6 ct. per day; 353 gal. per day up to and including first 5,000 gal. daily, 17 ct. per 1,000; then decreasing 1 ct. per 1,000 for each increased 5,000 gal. daily to 8 ct. per 1,000. For all over 50,000 gal. daily, 6 ct. per 1,000. Charitable institutions supplied water free.

Milwaukee, Wis.—(536,400.) 99 per cent metered. 7 ct. per 100 cu. ft. Service charge $2.00 per year.

Minneapolis, Minn.—(447,700.) 100 per cent metered. 8 ct. per 1,000 gal.

New Orleans, La.—(424,000.) 100 per cent metered. Less than 100,000 gal. per mo., 10 ct. per 1,000 gal. All over 100,000 gal. per mo., 7 ct. per 1,000 gal. Service charge per quarter: ⅝ in. meter, 75 ct.; ¾ in., 90 ct.; 1 in., $1.20; 1½ in., $1.80; 2 in., $3.00; 3 in., $4.50; 4 in., $6.00; 6 in., $10.50; 8 in., $18.00; 10 in., $27.00; 12 in., $36.00 One-quarter total consumption, not to exceed 600 gal. per quarter per person, free for sewerage purposes. Information from American City, July, 1926.

New York City—(5,870,000.) 25.7 per cent metered in 1925. 10 ct. per 100 cu. ft.

Oakland, Cal.—(267,300.) 100 per cent metered. (Private company.) First 50,000 cu. ft. per month, 23 ct. per 100; all over 50,000 cu. ft., 19 ct. per 100. Service charge: ⅝ in. meter, 50 ct. per mo.; ¾ in., $1.00; 1 in., $1.50; 1½ in., $2.50; 2 in., $4.50; 3 in., $8.00; 4 in., $12.50; 6 in., $25.00. Subcharge, 10 per cent of charges.

Omaha, Neb.—(219,200.) 97 per cent metered. First 14,000 cu. ft. per mo.; 12½ ct. per 100 cu. ft.; next 36,000, 9 ct. per 100; next 95,000, 7½ ct. per 100; next 1,230,000, 6 ct. per 100; all over 2,230,000 cu. ft., 6 ct. per 100 cu. ft., flat rate for total quantity. Minimum monthly rate, 35 ct.

Philadelphia, Pa.—(2,035,900.) 7.7 per cent metered. Minimum meter rates per year and quantities of water allowed therefor.

½ in. ferrule	$ 8.00	minimum,	8,000 cu. ft.
⅝ in. ferrule	12.00	minimum,	12,000 cu. ft.
¾ in. ferrule	18.00	minimum,	18,000 cu. ft.
1 in. ferrule	32.00	minimum,	32,000 cu. ft.
1¼ in. ferrule	50.00	minimum,	50,000 cu. ft.
1½ in. ferrule	75.00	minimum,	75,000 cu. ft.
2 in. ferrule	130.00	minimum,	130,000 cu. ft.
3 in. ferrule	290.00	minimum,	290,000 cu. ft.
4 in. ferrule	515.00	minimum,	515,000 cu. ft.
6 in. ferrule	1,150.00	minimum,	1,150,000 cu. ft.

All water in excess of this fixed amount, 40 ct. per 1,000 cu. ft.

Pittsburgh, Pa.—(665,500.) 40 per cent metered. First 250,000 gal. per quarter, 18 ct. per 1,000 gal; next 250,000, 16 ct. per 1,000; next 250,000, 14 ct. per 1,000; all over 750,000 per quarter, 12 ct. per 1,000. (Public Works, Sept. 1926.)

Portland, Ore.—(258,288, 1928 census, no estimate.) 100 per cent metered. For the first 20,000 cu. ft. per month, 9½ ct. per 100; all over 20,000 cu. ft., 7½ ct. per 100. Minimum charge, 60 ct. per month.

Providence, R. I.—(280,600.) First 10,000 cu. ft. quarterly, $1.80 per 1,000; next 90,000, $1.20 per 1,000; all over 100,000; 75 ct. per 1,000. Minimum charge, $8.00 per year. 1924 rate. No later information received.

Rochester, N. Y.—(324,500.) 99 per cent metered. First 20,000 cu. ft. or less, per month, $1.35 per 1,000; next 80,000, $1.20 per 1,000; all over 100,000, 75 ct. per 1,000. Minimum charge $1.50 per quarter.

St. Louis, Mo.—(839,200.) 7.7 per cent metered. Use per 6 mo.

For the first	3,000 cu. ft.	15c	per 100.
For the next	3,000 cu. ft.	14c	per 100.
For the next	4,000 cu. ft.	13c	per 100.
For the next	5,000 cu. ft.	12c	per 100.
For the next	10,000 cu. ft.	11c	per 100.
For the next	15,000 cu. ft.	10c	per 100.
For the next	100,000 cu. ft.	9c	per 100.
For the next	260,000 cu. ft.	8c	per 100.
For the next	3,600,000 cu. ft.	7c	per 100.
For the next	4,600,000 cu. ft.	6½c	per 100.
For the next	10,000,000 cu. ft.	6c	per 100.
For the next	18,000,000 cu. ft.	5c	per 100.

Minimum bill, $1.00. Manufacturing rates to consumers of over 60,000 cu. ft. semi-annually; for the 1st 60,000 cu. ft., 10 ct. per 100; next 440,000, 6 ct. per 100; next 500,000, 5½ ct. per 100; for all over 1,000,000 cu. ft., 5 ct. per 100.

St. Paul Minn.—(250,000.) 99.5 per cent metered. First 10,000 cu. ft. per mo., 9 ct. per 100; 10,000-50,000 cu. ft., 6 ct. per 100; 50,000 to 500,000 cu. ft., 4½ ct. per 100; all over 500,000 cu. ft., 3 ct. per 100. Service charge: ½ in., or ⅝ in. meter, $3.00 per year; ¾ in., $4.20; 1 in., $7.20; 1¼ in., $10.20; 1½ in., $13.20; 2 in., $27.00; 3 in., $60.00; 4 in., $120; 6 in., $240; 8 in., $420; 10 in., $600.

San Francisco, Calif.—(576,000.) 100 per cent metered. (Private company.) First 3,300 cu. ft. per month, 28.8 ct. per 100; next 30,000 cu. ft., 25.2 ct. per 100; all over 33,300, 21.6 ct. per 100. Service charge—monthly: ⅝ in. meter, 78 ct. per mo.; ¾ in., $1.20; 1 in., $1.80; 1½ in., $3.00; 2 in., $5.40; 3 in., $9.60; 4 in., $15.00; 6 in., $30.00; 8 in., $48.00.

Seattle, Wash.—(315,312.) 100 per cent metered. 500 cu. ft. or less, 50 ct. per mo.; over 500 cu. ft., 6 ct. per 100 cu. ft. For manufactories, laundries, motors and elevators, water in excess of 30,000 cu. ft., per mo., 4 ct. per 100 cu. ft.

Toledo, O.—(305,400.) First 10,000 cu. ft. per mo. $1.00 per 1,000; next 150,000, 90 ct. per 1,000; next 1,000,000, 70 ct. per 1,000; over 1,160,000, 50 ct. per 1,000. Minimum monthly charge, 80 ct. Information from Toledo City Journal, June 19, 1926.

Washington, D. C.—(540,000.) 86 per cent metered. Minimum rate, $5.65 per year for 7,500 cu. ft. of water. All in excess of this amount, 5 ct. per 100 cu. ft.

Standard Specifications for Cold Water Meters—Disc Type

Adopted June 9, 1921, by the American Water Works Association and September 14, 1921, by the New England Water Works Association

Cases.—All meters shall have an outer case with a separate inner chamber in which the disc operates. The outer case for all 2-inch and smaller meters shall be of bronze composition. Cast-iron frost bottoms may be provided. The outer case for meters larger than 2 inch shall be of bronze composition or of cast iron protected by a non-corrosive treatment.

All meters shall have cast on them in raised characters the size and the model and the direction of the flow through the meter shall be properly indicated. Meters larger than 1-inch shall be designed for easy removal of all interior parts without disturbing the connections to the pipe line.

External Bolts.—All external bolts shall be made of bronze or of galvanized iron or steel. Nuts shall be designed for easy removal after having been long in service.

Registers.—Registers may be either "round" or "straight" reading, indicating in cubic feet or gallons.

All parts of the registers shall be made of non-ferrous material. The maximum indication of the initial dial and the minimum capacity of the register, when indicating cubic feet, shall be as follows:

Size inches	*Maximum indication of initial dial cubic feet*	*Minimum capacity of register cubic feet*
⅝	1	100,000
¾	10	1,000,000
1	10	1,000,000
1½	10	1,000,000
2	10	10,000,000
3	10	10,000,000
4	100	100,000,000
6	100	100,000,000

All dials, including the initial dial, shall be subdivided into ten equal parts. All hands or pointers shall taper to a sharp point. They shall be accurately set and securely held in place.

Register Boxes.—Register boxes and lids shall be made of bronze composition or same material as the top case, with the name of the manufacturer cast on the lid in raised letters. The serial number of the meter shall be plainly stamped on the lid. If required, the serial number shall also be stamped on the case. The lid shall be recessed and shall lap over the box to prevent dirt from accumulating on the glass. The glass shall be inserted from the inside and securely held in place without the use of putty or pins. All register compartments shall be provided with a water-escape hole ⅛ inch in diameter, so placed that the change gear or registering mechanism cannot be tampered with.

Connections for ⅝, ¾ and 1-Inch Sizes.—Spuds shall be threaded ¾, 1 and 1¼ inch respectively, male thread standard pipe size and so threaded that Briggs standard pipe thread ring gages may be screwed on by hand within one thread of through the gage.

Over-all lengths of meters, face to face of spuds, shall be:

Size	*Length*
⅝ inch	7½ inches
¾ inch	9 inches
1 inch	10¾ inches

Couplings shall be made of bronze composition. Nuts shall be tapped ¾, 1 and 1¼ inch respectively, straight thread, standard pipe size and so tapped that Briggs standard pipe thread plug gages may be backed into the nuts by hand, i. e., the size of the thread in the nut is the maximum size of the Briggs plug, but no larger. Tail pieces shall be threaded ½, ¾ and 1 inch respectively, male thread, standard pipe size and so threaded that Briggs standard pipe thread ring gages may be screwed on by hand, flush with the face of the gage.

Over-all lengths of tail pieces shall be:

Size	*Length*
⅝ inch	2⅜ inches
¾ inch	2½ inches
1 inch	2⅝ inches

Connections for 1½ and 2-Inch Sizes.—Spuds shall be tapped 1½ and 2 inch respectively, female thread, standard pipe size, and so tapped that Briggs standard pipe thread plug gages may be screwed on by hand up to the notch on the plug.

Over-all lengths of meters, face to face of spuds, shall be:

Size	*Length*
1½ inch	12⅝ inches
2 inch	15¼ inches

Couplings shall be made of bronze composition. Nuts shall be tapped 2 and 2½ inch respectively, straight thread, standard pipe size and so tapped that Briggs standard pipe thread plug gages may be backed into the nuts by hand, i. e., the size of the thread in the nut is the maximum size of the Briggs plug, but no larger. Tail pieces shall be threaded 1½ and 2 inch respectively, male thread, standard pipe size and so threaded that Briggs standard pipe thread ring gages may be screwed on by hand flush with the face of the gage. 2 by 1½-inch and 2½ by 2-inch standard pipe size malleable iron bushings are to be furnished with 1½-inch and 2-inch couplings respectively. Care shall be taken to see that nuts as above described can be screwed on to the bushings by hand and that the face of the bushings will be sufficiently true and square to provide a proper packing surface.

Over-all lengths of tail pieces shall be:

Size	*Length*
1½ inch	2⅞ inches
2 inch	3 inches

Connections for 3, 4 and 6-Inch Sizes.—Spuds shall be flanged faced and drilled. Companion flanges shall be of cast iron, faced, drilled and tapped. All dimensions, drilling and tapping shall conform exactly to American standard of January 1, 1914.

Over-all lengths of meters, face to face of flanges, shall be:

Size	*Length*
3 inch	24 inches
4 inch	29 inches
6 inch	36½ inches

Seal Wire Holes.—⅝, ¾, 1, 1½ and 2-inch meters shall have register box screws and coupling nuts drilled for seal wire holes. Meters larger than 2 inch in size shall have register box screws drilled for seal wire holes. All seal wire holes shall be not less than 3/32 inch in diameter.

Measuring Chambers.—The measuring chamber for all meters shall be made of bronze composition and shall not be cast as part of the outer casing. It shall be machined with great care and secured in position in the outer casing so that any slight distortion of the casing which might take place under 150 pounds working pressure will not affect the sensitiveness of the meter.

Discs.—Disc pistons shall be made of vulcanized rubber and shall be fitted accurately but freely in their chambers. Vulcanized rubber pistons shall have a metal reinforcement or a thrust roller.

Intermediate Gear Trains.—The intermediate gear trains shall be of such construction as to be easily removed and shall be made throughout of non-ferrous material. Gear spindles may run in bearings bushed with hard rubber, provided the bushings are so constructed that they cannot drop out.

Strainers.—All meters shall be provided with strainers except when self-strained by means of an annular space between the measuring chamber and the external case. Strainers shall be made of non-ferrous materials and shall fit tightly against the wall of the casing. They shall have an effective straining area as large as practicable and at least double that of the inlet.

Registration.—The registration on the meter dial shall indicate the quantity recorded to be not less than 98 per cent nor more than 102 per cent of the water actually passed through the meter while it is being tested at rates of flow within the limits specified herein under "normal test flow limits." There shall be not less than 90 per cent of the actual flow recorded when a test is made at the rate of flow set forth under "minimum test flow."

Size, inches	*Normal test flow limits, gallons per minute*	*Minimum test flow, gallons per minute*
⅝	1 to 20	¼
¾	2 to 34	½
1	3 to 53	¾
1½	5 to 100	1½
2	8 to 160	2
3	16 to 315	4
4	28 to 500	7
6	48 to 1000	12

Capacity.—New meters shall show a loss of head not exceeding 25 pounds per square inch, when the rate of flow is that given in the following table:

Size, inches	*Gallons per minute*
⅝	20
¾	34
1	53
1½	100
2	160
3	315
4	500
6	1000

Pressure Test.—Disc meters shall be guaranteed to operate under a working pressure of 150 pounds per square inch without leakage or damage to any part.

Workmanship and Material.—Disc meters shall be guaranteed against defects in materials and workmanship for a period of one year from date of shipment. Parts to replace those in which a defect may develop within such period shall be supplied without charge, piece for piece, upon the return of such defective parts to the manufacturer thereof or upon proper proof of such defect.

Rejected Meters.—The manufacturer shall at his own expense replace or satisfactorily readjust all meters rejected for failure to comply with these specifications.

INFORMATION TO BE FURNISHED TO METER MANUFACTURERS WHEN REQUESTED TO SUBMIT BIDS ON DISC METERS

1. Meters shall conform to the Standard Specifications for Cold Water Meters, Disc Type, adopted by the American and New England Water Works Associations.

2. The manufacturer shall state in his bid the type of meter he proposes to furnish, as listed in his catalogue. The actual capacity of each size of meter called for is to be given graphically from 0 pounds up to 25 pounds loss of pressure. If this capacity be stated in the manufacturer's catalogue references may be made thereto.

3. No bid will be considered on meters of a design which has not been listed for at least one year in the catalogue regularly issued by the manufacturer.

4. The method of testing meters shall conform to that recommended by the Committee on Standard Specifications for Water Meters.

5. (a)* The meters are to be accepted on a certificate furnished by the manufacturers that the meters have met the requirements of the Standard Specifications for Water Meters, as adopted by the American and New England Water Works Associations.

(b)* The meters will be tested by the purchaser to determine whether they do or do not comply with the Standard Specifications for water meters adopted by the American and New England Water Works Associations.

6. Registers shall be {round / straight} reading, and shall record in {cubic feet / gallons}

*Sentence (a) is to be used where the purchaser does not have suitable equipment to test the meters. If he has such equipment then sentence (b) is to be used.

EQUIPMENT NECESSARY TO TEST METERS FOR COMPLIANCE WITH REGISTRATION AND CAPACITY REQUIREMENTS AS SET FORTH IN THE STANDARD SPECIFICATIONS FOR WATER METERS

The standard specifications require that meters shall accurately record the flow within certain limits and shall pass a given quantity of water with a maximum loss of pressure. Suitable equipment to make accurate tests must be available before the purchaser should make complaint of meters not complying with the specifications.

The minimum test equipment required for registration and capacity is as follows:

1. A quick-acting valve on the supply pipe through the use of which the flow can be started and stopped without appreciable loss of time.

2. A valve on the outlet side of the meter which can be used to establish the rate of flow desired.

3. Pressure gages connected on both the inlet and outlet of the meter to show whether any material change in pressure occurs during the period of test which would affect the rate of flow. The outlet pipe is to have sufficient head on it so that the meter will always have pressure on its outlet end and preferably not less than 5 pounds per square inch.

4. A measuring device which may be either of the volumetric or weighing type. Whichever is used, the accuracy of determination of the volume or weight of water discharged into the measuring device must be such as to bring the limit of error within one-tenth of 1 per cent. The volume of water passed must be sufficient to cause at least one revolution of the pointer on the initial dial except for test at "minimum test flow" rate. For the latter test, the amount passed shall not be less than one cubic foot.

It is desirable to have available for testing meters a test table and appurtenances which are manufactured by several concerns. Such an outfit would include the equipment enumerated in the preceding four paragraphs.

For the capacity tests, it is necessary to add to the above equipment, two piezometer rings which must be of exactly the same diameter. The piezometer rings must be free from any burrs where the holes are drilled through the wall of the ring and not less than four holes shall be provided, drilled in pairs and on diameters at right angles to one another. The inlet piezometer ring shall be set close to the meter and shall be at a distance of not less than eight diameters from the nearest upstream stock-cock or fitting in the supply pipe. The outlet piezometer ring shall be placed at a distance of not less than eight nor more than ten diameters from the outlet of the meter. The diameter of the piezometer rings and inlet and outlet pipes shall be the same as the size of the meter to be tested. The piezometer rings are to be connected by either rubber or metal tubing to a mercury U-tube. To this U-tube is to be attached an accurate adjustable scale for measuring the differences between the inlet and outlet pressures. Provision is to be made for the complete removal of air from the tubing connected with the U-tube, and the U-tube and the tubing connected therewith are to be so placed that the air will rise to the outlets. Where relatively high flows are to be recorded, it is necessary to read both sides of the mercury column to compensate, as far as practicable, for irregularities in the diameter of the glass U-tube and such readings are to be made as nearly simultaneously as possible to avoid errors due to fluctuations.

TESTS OF METERS RECOMMENDED

The tests to be made on the meter are divided into two classes: 1, Capacity test; 2, Registration test.

Capacity tests are those which test the design of the meter rather than the workmanship thereof. When a meter of a given make has once been tested for capacity it should not be necessary to again test this type of meter unless a change has been made in its design.

The registration tests should be made on each meter, as the results are affected by workmanship and assembly of individual meters. There is no certainty that, because one meter of a given make comes within certain limits of accuracy, another meter of the same make turned out by the factory on the same day will necessarily give similar results. The register furnished with each meter should be used by both the manufacturer and purchaser in making registration tests. Where the purchaser does not have the necessary equipment to test the meters, there should be furnished by the manufacturer a certificate that each meter has been tested for accuracy of registration and complies with the standard specifications in this respect, and that the type of meter furnished has complied with the capacity requirements.

The registration tests recommended are as follows:

All meters should be tested for accuracy of registration within and as near as practicable to the low and high rates given under "Normal Test Flow Limits."

A test at the "Minimum Test Flow" should be made on as many as possible and not less than 5 per cent of the meters. If the results obtained from testing 5 per cent of the meters show that any meter does not comply with the low flow requirement, additional meters should be tested to the extent deemed necessary to make certain that the other meters do comply therewith.

The pressure test should be made on each size of meter furnished of a particular type. This pressure is to be 150 pounds per square inch and the pressure may be furnished through the use of a hand pump or such other method as may be available. Before the meter has been tested by static pressure and also after it has been so tested, it should be tested for accuracy to see whether the meter has been so distorted as to affect registration. It is considered unnecessary to make a pressure test of each size of meter of a given type more than once if satisfactory results are obtained.

If it be possible to give a working pressure test under 150 pounds per square inch then such a test should be applied rather than a static pressure test.

Data on Consumption, Per Cent of Services Metered and Water Rates for Various Cities

From Water Works

City	Population Served 1920	Average Daily Consump. (mgd.) 1924	Per Cent of Services Metered		Per Capita Water Consumption in gallons per day							Average Water Rate[A] per 1000 gallons		
			Aver. 5 yrs. 1920-24	1924	1920	1921	1922	1923	1924	Average 5 years 1920-24	Probable Present Safe Amt.	Gallons per Month 25,000 (Domest.)	250,000 (Intermed.)	2,500,000 (Mfg.)
New York City, N.Y.	5,663,980[C,D,E]	789.2[C]	26	25	130.[C]	127.[C]	128.[C]	131.[C]	131.[C]	129.[C]	135[C]	$0.13	$0.13	$0.13
Mass. Metropolitan Dist.	1,213,430[B]	124.10	82	95	105.	95.	94.	97.	95.	97.	100	0.21[J]	0.19[J]	0.18[J]
Detroit, Mich.	1,061,972	183.97	98	99	143.	143.	148.	135.	134.	141.	140	0.10[J]	0.08[J]	0.06[J]
Cleveland, O.	925,283	151.18	98	98	151.7	135.0	137.3	149.6	140.8	142.9	145	0.08	0.08	0.08
Boston, Mass.	751,810[D]	87.68	73	94	125.	112.	110.	113.	111.	114.	115	0.21	0.19	0.18
Milwaukee, Wis.	500,000	69.02	98	99	133.8	122.2	124.5	132.0	125.4	127.6	130	0.10[J]	0.09[J]	0.09[J]
Cincinnati, O.	414,500	48.94	100	100	119.4	114.7	117.0	115.6	115.1	116.4	120	0.16	0.16	0.16
Newark, N.J.	414,216	43.6	94	96	108.2	91.8	95.4	99.8	97.8	98.6	100	0.15[J,K]	0.14[J,K]	0.13[J,K]
Minneapolis, Minn.	380,582	42.77	100	100	98.8	100.0	100.0	107.0	102.5	101.7	105	0.08	0.08	0.08
Kansas City, Mo.	334,193	48.33	81	83	142.6	132.3	138.3	132.5	125.9	134.3	135	0.22	0.17	0.11
Rochester, N.Y.	278,000	26.4	99	99	95.7	96.2	88.8	86.3	85.6	90.5	90	0.18	0.17	0.15
Providence, R.I.	270,472	23.62	94	95	80.	78.5	81.2	86.	83.	82.	85	0.24	0.17	0.11
Toledo, O.	243,164	29.	99	100	104.	101.	109.	106.	102.	104.	110	0.13	0.12	0.11
Columbus, O.	240,000	23.20	99	99	94.1	82.3	83.6	88.5	85.9	86.9	90	0.16	0.16	0.15
St. Paul, Minn.	234,698	20.38	96	98	81.2	80.7	81.6	80.1	72.7	79.3	80	0.09[J]	0.09[J]	0.09[J]
Worcester, Mass.	179,923	16.27	97	98	92.1	82.5	84.5	85.1	84.5	85.7	90	0.20	0.15	0.10
Hartford, Conn.	165,000	16.16	100	100	78.6	76.7	84.1	95.6	88.8	84.8	90	0.16	0.16	0.10
Grand Rapids, Mich.	145,000	15.91	99	99	98.	94.	98.	113.	99.	100.	105	0.09	0.09	0.09
New Bedford, Mass.	131,350	9.71	95	93	78.	71.	71.	77.	67.	73.	75	0.16[J,L]	0.10[J,L]	0.10[J,L]
Springfield, Mass.	130,114[E]	13.52[E]	99	99	96.[E]	90.[E]	87.[E]	91.[E]	89.[E]	91.[E]	95[E]	0.18	0.08	0.07
Fall River, Mass.	124,843	6.79	100	100	51.1	55.3	49.5	54.1	51.9	52.4	55	0.28	0.20	0.14
Lowell, Mass.	112,759	6.54	89	90	63.4	58.0	56.1	54.5	52.3	56.9	60	0.28	0.28	0.28
Yonkers, N.Y.	101,176	13.41[F]	100	100	110.[F]	105.[F]	114.[F]	112.[F]	122.[F]	113.[F]	120[F]	0.21[J]	0.13[J]	0.13[J]
Lawrence, Mass	94,270	4.64	96	97	49.	43.	46.	46.	45.	46.	50	0.20	0.20	0.20
Brockton, Mass	80,206	4.19	100	100	43.3	43.6	43.9	47.3	50.0	45.6	50	0.26[J]	0.16[J]	0.14[J]
Manchester, N.H.	80,000	6.35	83	85	67.7	66.5	68.4	76.2	76.6	71.1	75	0.13	0.13	0.10
Woonsocket, R.I.	48,360	3.01[H]	96[H]	96[H]	53.	50.7	53.8	59.8	-	54.3[M]	60	0.28	0.14	0.10
Madison, Wis.	38,378	4.77	100	100	102.	99.	101.	106.	102.	102.	105	0.12[J]	0.09[J]	0.06[J]
Waltham, Mass.	31,000	2.23	98	100	63.8	63.2	67.2	65 5	65.5	65.0	70	0.22	0.15	0.15
San Francisco, Cal.[B]	506,676	39.31	100	100	71.4	70.3	63.7	62.2	58.2	65.2	65	0.40[J]	0.33[J]	0 30[J]
												(Domest.) 3/4"	(Intermed.) 2"	(Mfg.) 6"

[J] Includes service charge.—Assumed size of meter for stated quantities.

[A] Rates averaged to nearest cent only.

[B] Private company.

[C] Includes supply from both municipal and private works.

[D] Population for July 1, 1920

[E] Data given on basis of population of "Springfield District" only

[F] Consumption in Yonkers high on account of sugar refineries and other manufacturing plants.

[H] For 1923.

[M] Average for four years 1920-1923

[I] Weighted average.

[K] Rates for high pressure service are 1/3 higher

[L] Rate for purposes other than manufacturing.

[M] Rate for manufacturing purposes.

H. W. CLARK COMPANY

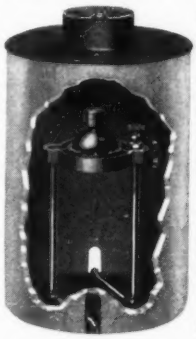
Manufacturers of Water Works Necessities

Mattoon, Illinois, U. S. A.

"The Sun Never Sets on Clark Products"

Products: CLARK METER BOXES, METER COUPLINGS, COUPLING YOKES, METER TESTERS; SERVICE BOXES, VALVE BOXES AND HOUSINGS; TROUBLE-FINDING INSTRUMENTS; CURB COCK REPLACERS, VISE FOR BRASS PIPE, TEXAGON COUPLINGS, MUNICIPAL CASTINGS.

The Clark Meter Box (Northern Type): In climates where the winter frosts penetrate the ground, The Clark Northern Meter Box has been the choice of water works men for over twenty-five years. Clark Meter Boxes afford thorough protection from street traffic, from frost, and from tampering. The meter can always be read, and the lock never becomes inoperative, even if it has not been used for years. Meters are read quickly, and provision is made for the ready accessibility for repairs or replacement of meter.



Covers and lids are furnished in sizes for box bodies 15″, 18″, 20″, and adapters for larger sizes. Box Bodies, vitrified earthenware, are furnished in the above diameters and in lengths from 1′ to 3′, or they may be made of concrete by use of the Clark Iron Collapsible Form described in catalog.

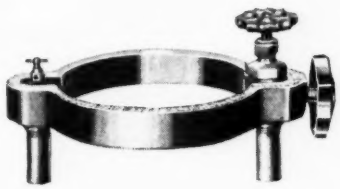
Improved Perfect Lock For Northern Type Lid: The Clark refined and highly developed perfect lock—which keeps the lid tight, yet opens easily—operated by one-third turn of key. Locking Bolt is of one piece construction and is made of forged manganese bronze having a tensile strength of 60,000 lbs.

The Clark Meter Box (Southland Type): For moderate climates, The Clark Southland Meter Box meets every requirement. Made in four cast-iron types and sizes, in round and oval shapes; sheet-iron meter boxes, and rings and lids for use on concrete box bodies.

Improved Wonder Lock (For Southland Box): The refined and highly perfected Wonder Lock for Southern Meter Boxes is of bar and cam construction, assembled without use of screws, rivets or bolts. It is secure, easily operated and always dependable. Bars are of manganese bronze. Key serves as handle and cannot be taken out until Box is securely locked.

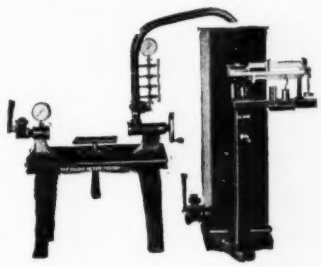
The Aristocrat Key (Long Handled): For use with Clark Southland Boxes and Wonder Lock—the meter reader does not have to stoop over to unlock or lock box or to read meter. A great time saver.

C. M. B. Service Box: Used with or without extension rods. Plug is of cast iron with long screw, one thread to the inch, fitting into bronze bushing. Sliding extension is accomplished by telescoping of intermediate section into base, preventing surface loads or stresses being communicated to cock, which is securely held in a central location, and engagement of wrench is assured.



Meter Coupling Yokes (Circular Type): Because of its circular construction, this yoke combines great strength with light weight and amply provides for contraction or expansion. By removing frame with meter—service is automatically cut off and possibility of unauthorized use of water eliminated.

Meter Testers: Manufactured in eleven sizes, in both single and multiple models in weighing, volumetric or combination types to meet the conditions of every water department, large or small.



Valve Boxes and Housings: Valve Boxes 5¼″ inside diameter. Valve Housings furnished in all-cast-iron construction, and Covers and Lids for use on concrete bodies made by Clark Iron collapsible forms.

Catalogs: The Clark Line of water works necessities is complete and is made up of equipment and accessories that have been developed by practical water works engineers to meet definite needs—and to meet such needs efficiently, economically and in a practical way.

Write for Catalog 27 describing our complete line of Water Works Necessities, also bulletin of Municipal Castings.

READING METER REPAIR COMPANY

Reading, Pennsylvania

Hydraulic Supplies and Equipment for Water Works, Sewerage and Drainage Systems

WATER AND OIL METERS REPAIRED, REBUILT, TESTED

Products: HYDRAULIC SUPPLIES AND EQUIPMENT FOR WATER WORKS, SEWERAGE AND DRAINAGE SYSTEMS, INCLUDING METER TESTERS, METER HOUSINGS, VALVE HOUSINGS, CURB BOXES, HEATERS, BURNERS, MELTING FURNACES, JOINTING MATERIALS, BRASS CLEANERS AND SCALE REMOVERS, MISCELLANEOUS WATER WORKS TOOLS, PUMPS, DRAINAGE CASTINGS, VALVES AND FIRE HYDRANTS. WATER WORKS SPECIAL CASTINGS AND APPLIANCES.

"Reading" Meter Box Covers are exceptionally roomy, permitting removal and replacing of meters without digging; besides, when placed at the curb line, providing space for a stop cock and making a separate curb box unnecessary. Figure B-4 shows a standard meter setting, with a "Reading" Meter Box cover mounted on a section of sewer pipe and enclosing a meter, with stop cock, test tee, combination stop and check-valve and relief valve. By this arrangement no key is required to turn on or shut off the service, meter readings are speeded up and cellar experiences are obviated, thus saving both time and money.

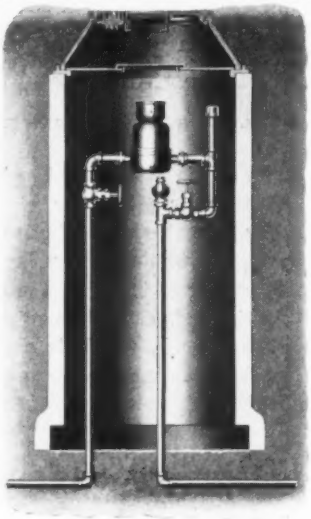


Fig. B-4

The "Reading" Meter Box Cover, Fig. B-1, is not only the most roomy but has the best locked lid on the market. Fig. B-2 shows the specially designed locking device which is operated with the five-cornered socket wrench used on curb box lids. It is interference and fool-proof.

The inner or frost lid, Fig. B-3, which absolutely protects the meter from the cold, is designed to facilitate meter reading.

Gate Valve Housings—the Reading, Non-Breakable, Non-Tilting, Noiseless Gate Boxes

"Reading" Gate Valve Housings are non-breakable, non-tilting, noiseless and of sufficient size to admit a workman, as shown in Fig. C-1. Where these boxes are used there is no necessity for digging up streets to repair valves. These housings are especially valuable where there is permanent paving. A heavy section of metal at the center prevents lids from breaking under heavy loads, and lead gaskets deaden the sound of passing vehicles. Rings care for variations in heights of 1½ in.

"Reading" Curb Box has no projections. There is nothing for the frost to lift and it will remain in place after years of service; in marked contrast to the old style boxes that are lifted whenever the surrounding ground freezes, presenting a menace to pedestrians and an incentive to damage suits. The "Reading" Box is adjustable to any depth of planting. Fig. D-1 shows the "Reading" box complete and D-2 presents a close-up view of the lid and locking device.

"Reading" Combination Furnace is built for melting lead and lead substitutes with wood, coal or coke, or with oil-burning torches. It is constructed of the best quality of heavy cast iron and fully meets all melting furnace requirements.

"Reading" Joint Cement is especially adapted for threading joints of wrought iron and steel pipe, and the other uses to which red lead is usually applied.

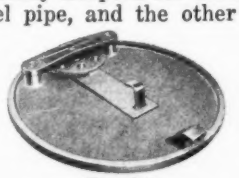


Fig. B-2

"Reading" Brass Cleaner and Scale Remover eliminates the use of acids and an acid room, in the cleaning of bronze or brass castings and the removal of scale incrustations from metal surfaces. Objects cleaned with this solution, without noxious fumes and at a fraction of the cost, are as bright as those on which acids have been used.

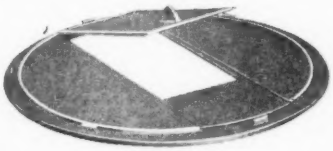


Fig. B-3

Meter Repairing: In the well-equipped Meter Repairing Department, expert and experienced specialists repair, adjust and test water and oil meters of all makes and sizes at moderate cost and with a guarantee of satisfactory functioning.

Fig. B-1

Fig. D-1

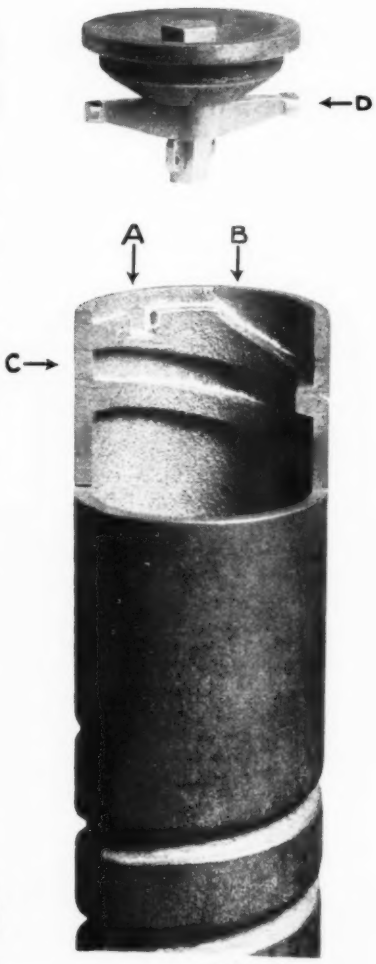


Fig. D-2

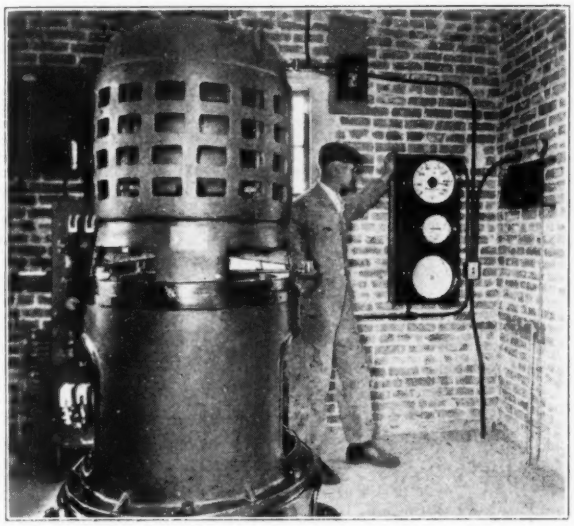
REPUBLIC FLOW METERS CO.

2258 Diversey Parkway, Chicago, Ill.

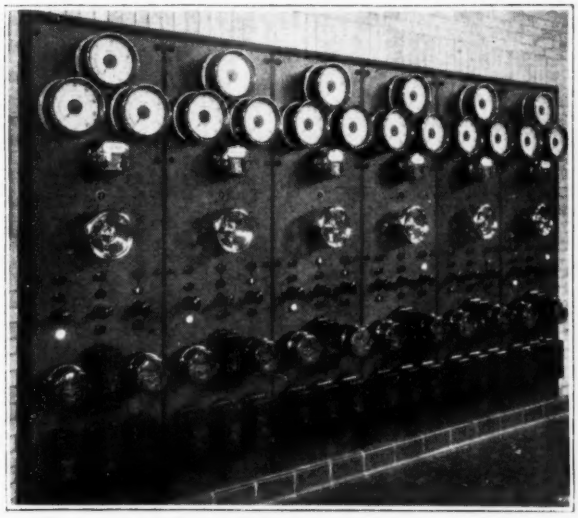
Branch Offices in 25 Principal Cities

Dominion Flow Meters Co., 129 Adelaide St., West Toronto, Canada

Electroflo Meters Co., Ltd., Abbey Road, Park Royal, London, N. W. 10, England



Republic Water Meter on Individual Well Pump—Westmont, Ill.



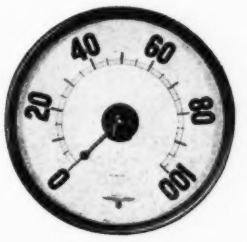
Republic Meters at Detroit High Pressure Pumping Station

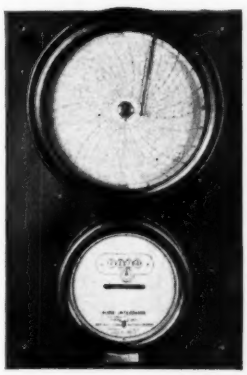
Republic Products: STEAM METERS, WATER METERS, GAS METERS, AIR METERS, CO-2 METERS, PYROMETERS, PRESSURE GAGES, LIQUID LEVEL INSTRUMENTS.

Republic Water Meters have several distinct advantages over any other type of master water meter. The reading instruments being electrically operated, can be placed any distance from the point of measurement. This permits the indicating, recording and totalizing of all flows to be centralized on one panel remote from the individual meters.

Electrical operation permits the control of outlying well pumps from a central control station providing a definite record as to when the pump started and stopped, the number of hours it operated and the total water discharged.

In filtration plants electrical operation permits the reading instruments to be located on the operating table or at any near by or remote point. Only with electrically operated meters is it possible to have simultaneous indications of the washing rate furnished on each control table.





Republic Reading Instruments

The reading instruments can be had in any combination of those shown on the panel at the right, namely: indicating, totalizing and recording.

Republic Advantages

1.—No mechanical moving parts such as levers, cams or floats.

2.—A very small pressure differential is required.

3.—Variation of voltage in current supply does not affect the readings.

4.—Sudden surges of pressure or flow cannot harm meter body.

5.—Foreign matter cannot enter the meter body.

6.—Reading instruments can be located any distance from point of measurement.

7.—Three separate instruments for three distinct types of readings.

Write for bulletin "Republic Water Meter" which contains a complete description of the construction, operation and application of Republic Water Meters.

SIMPLEX VALVE & METER COMPANY

6749 Upland Street, Philadelphia, Pa.

SIMPLEX REPRESENTATIVES

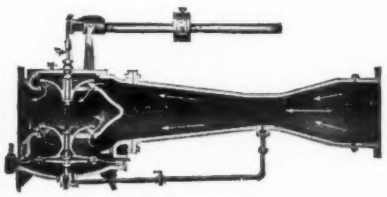
American Pump and Supply Company, General Motors Bldg., Detroit, Michigan.
A. F. Barron, 30 North Michigan Blvd., Chicago, Illinois.
C. C. Behney, 718 Empire Building, Pittsburgh, Pa.
Daniel, Inc., 814 Metropolitana Bldg., Havana, Cuba.
M. N. Dannenbaum, Bankers Mortgage Bldg., Houston, Texas.
F. H. Dorner, 311 Knapp Street, Milwaukee, Wisconsin.
Denver Fire Clay Company, Denver, Colorado.
F. Hankin and Co., Ltd., 2028 Union Avenue, Montreal, P. Q., Canada.
F. Hankin and Company, Ltd., 165 Spadina Avenue, Toronto, Ont., Canada.
Kent Engineering Company, 718 Builders Exchange Bldg., Minneapolis, Minn.
Wm. J. Neville, Candler Bldg., Atlanta, Georgia.
O. G. Smith, 110 E. 40th St., Kansas City, Missouri.
Tomlinson, MacLachlan, Inc., 1601 St. Clair Avenue, Cleveland, Ohio.
W. K. Sowdon, Inc., 342 Madison Avenue, New York City, N. Y.
Geo. W. Stetson, 141 Milk Street, Boston, Mass.
W. D. Taulman, Union Indemnity Bldg., New Orleans, La.
Water Works Equipment Co., 149 West 2nd South St., Salt Lake City, Utah.
Water Works & Power Eqpt. Co., White Henry Stewart Bldg., Seattle, Washington.
Water Works Supply Company, 208 Sharon Bldg., San Francisco, Calif.
Water Works Supply Company, Wright and Callender Bldg., Los Angeles, Calif.

Products: SIMPLEX HOT AND COLD WATER METERS OF THE VENTURI TYPE, PITOT TUBES AND MANOMETERS; ALSO RATE OF FLOW CONTROLLERS; LOSS OF HEAD AND RATE OF FLOW GAUGES; PORTABLE PITOT TUBE CHART RECORDERS; WATER LEVEL GAUGES; AUTOMATIC AIR RELEASE VALVES; AIR AND VACUUM VALVES; PROPORTIONAL CHEMICAL FEED DEVICES, ETC.

Simplex Meter Registers: Are generally operated by venturi tubes; where necessary, are operated by pitot tubes, orifices, etc. They are used for measuring hot and cold liquids under all pressure conditions—for measuring boiler feed, condensate, circulating water, water supply, sewage, brine solutions, anhydrous ammonia, oil, etc. They are noted for their ability to operate under the smallest venturi heads to measure the lowest flows to respond to water differentials from one-eighth inch and upward.

To record each slight definite change in rate of discharge; to operate over the widest range with the greatest accuracy, their design includes an evenly spaced rate of flow dial, a rectangular recording chart, a dependable accurate totalizer and simple means for proving the accuracy of each function with the utmost accessibility and easy for necessary adjustments.

With each instrument is supplied mercury, tools, one year's supply of charts, spare pens, ink, printed instruction bulletin and water manometer testing appliance, by which the instrument may be set exactly correct, and at any time thereafter the correction of this adjustment may be verified.



Simplex Filter Rate of Flow Controllers. An essential device for efficient and safe operation of gravity or pressure type filters, which keep the rate of discharge through the sand bed constant regardless of variation in pressure or

CAPACITIES OF VENTURI TUBES AND SIMPLEX METER REGISTERS

Dia. Pipe, In.	Catalog No. for Ordering	Hot Water (200° F.) pounds per hour		Cold Water gallons per day	
		Maximum	Minimum	Maximum	Minimum
2	2x 25/32	18,150	900	.....	.....
	2x 29/32	24,700	1,250	.....	.....
	2x 1	30,000	1,500	.....	.....
	2x 1 1/16	40,000	2,000	.....	.....
3	3x 1	29,600	1,480	.....	.....
	3x 1 1/4	46,500	2,300	.....	.....
	3x 1 1/2	68,000	3,400	.....	.....
4	4x 1 17/32	69,500	3,500	.....	.....
	4x 1 3/4	92,000	4,600	.....	.....
	4x 2	122,000	6,100	356,000	18,000
5	5x 1 3/4	90,000	4,550	265,000	13,300
	5x 2	120,000	6,000	348,000	17,500
	5x 2 1/2	190,000	9,500	555,000	28,800
6	6x 2 1/2	187,000	9,350	547,000	27,400
	6x 2 3/4	228,000	11,400	665,000	33,500
	6x 3	274,000	13,700	800,000	40,000
8	8x 3	268,000	13,500	780,000	39,000
	8x 3 3/8	340,000	17,000	1,000,000	50,000
	8x 4	485,000	24,500	1,420,000	71,000
10	10x 4	.....	.....	1,400,000	70,000
	10x 5	.....	.....	2,220,000	111,000
	10x 6	.....	.....	3,320,000	166,000
12	12x 5	.....	.....	2,200,000	110,000
	12x 6	.....	.....	3,200,000	160,000
	12x 7	.....	.....	4,480,000	224,000
14	14x 6	.....	.....	3,170,000	160,000
	14x 7	.....	.....	4,360,000	220,000
16	16x 7	.....	.....	4,300,000	216,000
	16x 8	.....	.....	5,680,000	285,000
	16x 9 1/2	.....	.....	8,300,000	415,000
18	18x 9	.....	.....	7,200,000	360,000
	18x10	.....	.....	9,000,000	450,000
20	20x10	.....	.....	8,900,000	445,000
	20x12	.....	.....	13,300,000	666,000
	20x13	.....	.....	16,000,000	800,000

This is a partial list. Specific needs can be filled from the many other sizes available.

water level. The pressure effect of the water flowing through the filter effluent self-operates the controller. It consists of a balanced valve connected to an ample and substantial diaphragm, which is actuated by the difference in pressures due to the low velocity through the body and the high velocity through the throat. This differential pressure is balanced by a counter-weight carried on a beam with knife edge supports. The rate of flow may be changed by sliding the counter-weight.

The Simplex Controller is arranged for either "straight through" outlet (as shown in figure above) or "right hand" or "left hand" outlet as preferred—the Simplex is the original "direct acting, controller."

Simplex Filter Gauges: These may be had in many combinations of Indicating Recording and Totalizing, both the Rate of Flow and the Loss of Head.

They are mercury float operated, the Simplex Bell Shaped Float is utilized in the Rate Gauge which provides uniform graduations of flow on both the Indicating Dial and Recording Chart.

There are also available for measuring depth of water in clear wells, sedimentation basis, etc., Simplex water float operated gauges may be furnished in both Indicating and Recording or combined types.

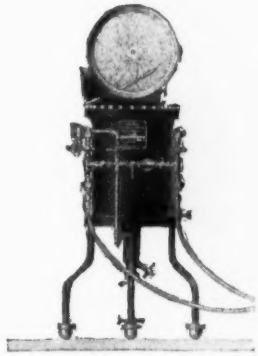
Simplex gauges are dependable, accurate and easily installed—a high grade quality product made with precision and care.

Simplex Valves for Pipe Lines: In the design and operation of large steel pipe lines flowing under gravity, consideration should be given to the possibility of collapse in case, for any reason, the internal pressure is reduced below that of atmosphere. A number of serious failures have been caused by the neglect to provide adequate means to prevent this possibility.

Simplex Air and Vacuum Valves for use on large mains where there is danger of collapse due to vacuum, the valve breaking the vacuum, preventing collapse.
Facilitates the filling of the main, since wide open until full of water.

They are made in the following sizes:
2″, 3″, 4″, 6″, 8″, and 10″. The 2″ size is furnished with a screw thread base for nipple connection to the main pipe line. The 3″ to 10″ sizes are designed for a flange connection as illustrated. This may be either low pressure or heavy pressure A. S. M. E. drilling. On the side there is provided a 1″ connection for attaching a Simplex Automatic Air Release Valve whose function is to take care of any small accummulation of air that may be entrapped in a pipe line—if this is not desired a manually operated air vent valve may be used or the top may be plugged. At the bottom on the side there is provided a drain plug.

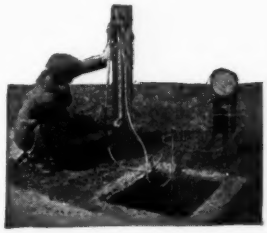
Simplex Automatic Air Release Valves: Nearly every water works superintendent has experienced trouble in connection with some phase of air in pipes. Simplex Automatic Air Release Valves have been designed to release Automatically accumulations of air. They possess the merits of continuous operation without attention, simplicity, compactness, accessibility and low cost, all of which are proved by over fifteen years satisfaction to many users. Located on the high portions of the line, they insure automatic venting of the line and a continuous flow.



Simplex Pitot Tube Recorder: For use with Simplex Round or Flat Pitot Rods—affords not only a record of velocity but can be furnished with pressure elements to give simultaneous readings of velocity and pressure.

This equipment may also be used for Water Waste Surveys or for conducting water flow investigations.

Indispensable to water works engineers for determining character of the flow in the mains of the distribution system.



Simplex Water Waste Surveys: A complete survey service conducted by competent Engineers, with Simplex Pitot Recorder Equipment.

Your inquiry will receive prompt attention and complete recommendations can be furnished.

Who Is Responsible for Water Bill?

The following interesting discussion in the respective responsibility of property owner and tenant for the payment of the bill for water furnished is taken from *Water Works:*

Property Owner Responsible at New Bedford, Mass.—In New Bedford we only recognize the property owner. We are all metered. Some of our large tenement houses have only one meter and the owner pays that bill. If he cares to sub-divide it between his tenants, he can do so by private meters, but, as far as the city is concerned, we look only to the owner for the water that goes into his property. We send our bill to the owner. If he passes it on to his tenant and he pays it, that is all right, but the owner of the property is the man we hold responsible for the charge for water in that property.—Stephen H. Taylor, Superintendent Water Works, New Bedford, Mass.

Property Owner Held Responsible.—In Minneapolis we hold the property owner responsible for all the water bills, although, if we have no mailing address to which to send the bill, it is mailed to the owner or occupant. Our real estate leases in Minnesota provide, the majority of cases, that the tenant pay their own water bills. While the property owner is held responsible, it is a matter of mutual agreement between the tenant and the owner as to which one pays it.—Wm. R. Young, Registrar Water Works, Minneapolis, Minn.

Wisconsin Law Regarding Unpaid Bills.—The state law of Wisconsin provides that any unpaid water bills that are not paid the first of November, are a charge against the property, so that any legislation on this matter must be based on the state law. The state law of Wisconsin provides that any charge whatever, either water bills or repairs on meters are a tax against the property. If those bills are unpaid the first of November, they are to be entered on the tax roll against the property. Our contracts are with the property owner. We have a signed contract with every consumer, that is signed by the owner of the property. The owner of the property owns the meter and is charged with the water bill, if it is not paid by the tenant or the holder of the land contract. That is a state law.—P. J. Hurtgen, Director of Public Works, Kenosha, Wis.

State Law for Lien on Property in Massachusetts.—In Massachusetts, we have a state law for a lien on the property, but you do not have to accept it, if you do not want it. The water department can accept it or not. We accepted it, but we did not want it very badly because our water commissioner's "yes" or "no" in two minutes is law with them. They could shut off or turn on the water if they were so inclined. They could cut off the water in two minutes, advertise your property and sell it. If we have a bad bill we send a man out to shut it off and if a woman gives him a check and the check is no good, he does not take any other check. There is a law in Massachusetts that, if you issue a bad check you go to jail, so there is no chance of a bad check. We allow them therefore to collect the bill.—Patrick Gear, Superintendent Water Department, Holyoke, Mass.

Property Owner Responsible at Sioux City, Ia.—We have 16,000 consumers in Sioux City and are 100 per cent metered. We hold the property owner responsible under our ordinances. In a city the size of ours we found in the last two years that a great many double houses, which formerly supplied two families, are being changed into flats, kitchenettes, etc. A great many of the larger houses are changed into duplexes. It is not practical for two meters and we insist on only one meter. We had it out with the real estate board some years ago. They were quite intent upon making the tenant responsible and letting the water department carry on a profit and loss system for their tenants. After discussing it for some time I wrote thirteen points for them showing why it was impractical. The landlords said the most expensive water they had would be the hot water. One tenant would use it one day and another another day. In the sprinkling season of the year, the sprinkling was done from one service and they could not separate it. There was so many objections to it, that they decided they would have to make it a matter between the landlord and the tenant. Our law makes it a lien against the property. It has been very rigidly enforced. For example, the department of education has some blocks where there were tenant houses. We knew nothing of it for some time and they allowed the tenants to remain. The tenants lately vacated the premises and we sent the bills to the department of education. They tried to repudiate them, but the city attorney said they were obliged to pay them for they were a lien against the property.—Phil. Carlin, Superintendent Water Works, Sioux City, Ia.

Owner Must Sign Contract.—In Wildwood, N. J., the owner must sign a contract and it is a lien against the property. We serve two other municipalities and the owner must sign for the water where it is not a lien against the property. We issue our bills the first of the year for the minimum charges. If they are not paid, we do not bother with them, but, in the other municipalities, we give them 60 days and at the expiration of that time if they do not pay, we give them a ten days' notice. It must be paid within that time or it is shut off without further notice. We make up an account in the form of districts. The man who makes the turn-off has the amount of the bill plus 1 per cent penalty a month. He must get the money at that time or shut off the water. In Wildwood, proper, where they owe a bill, where it is a lien against the property, we do not bother.—Wm. G. Banks, Newark, N. J.

Tenant Pays Bill in Most Cases.—We have 8,500 consumers. We do not hold the property owner responsible, except for properties where there are two meters. The tenant pays the water bill in most cases. The owner may, if he wishes to. We have no contact with the tenant. We require a deposit of $3.00 from each tenant, which is, of course, refunded if they move to some house where they do not use city water. We find that that works very nicely. We read our meters daily and bill daily, that is, we make bills delinquent fifteen days after the bills have been sent out. They receive then a second notice giving them ten days further extension. If the bills are not paid within that time, a shut-off ticket is made out and the water is turned off. They have the right or the privilege to pay the turn-off man with a dollar penalty, before the water is turned on.—McEvoy, Dubuque, Ia.

Lien Law in Pennsylvania.—In Pennsylvania the municipally owned plant has a right within three years after the bill comes due, to declare a lien upon the property for it. I do not know of a case where it has been done, for two reasons; in the first place, we can shut off the water and the landlord will pay to get the water turned on. The second reason is that the constable's fee is rather heavy. Here is always a question of whether you are justified in spending five or six dollars to collect a water bill of an equal amount. The tenants can pay the water bill if they want to. We send all our water bills by mail on a government postcard that costs us about a cent and a quarter for the card and the postage. On the face of it, it is addressed to the tenant or owner, and on the back is marked for the owner or the tenant. Either may pay it. In the last analysis it is the owner who has to pay the bill.

Advantages of Dealing with the Property.—In St. Paul we have properties standing in the name of an owner whose ownership ceased several years ago. New owners are paying the bill and we do not find more than a quarter of them that will take the trouble to come in and change the name on the records to indicate that they are the present owners. That is the advantage we have in saying that we are dealing with that property. We are interested in this property and want it to pay this bill. We cannot go into research concerning the responsibility of the present tenant, the former tenant or landlord or anything of that kind.—C. M. Crowley, Water Registrar, St. Paul, Minn.

Water Works Accounting

Uniform Classification of Accounts

Accounting may be defined generally as a procedure relating to the assembly and recording of facts in business transactions in an orderly, chronological manner, so that periodical statements may be rendered, showing the financial position of any business enterprise and the results from operation; and may be considered as the right hand of management or administration.

Uniform Classification of Accounts.—The National Association of Railroad and Utilities Commissioners have provided a uniform classification of accounts which were revised November, 1922, and goes into the matter of utility accounting in a very comprehensive manner, and up to 1925 a total of 25 states had adopted completely, or nearly so, this uniform classification. Nine commissions have no jurisdiction over this accounting; one has adopted the Federal Power Commission's classification and twelve more have the classification under consideration.

Value of Uniform Classification of Accounts.—One of the principal advantages of uniform accounting is that proper comparisons could be made in financial statements and where a holding company has interests in many states, it is very evident that a uniform classification is desirable. The California Water Service Company reports to the Federal Water Service Corporation of New York under the national association of railway and utilities classification, according to R. B. F. Chisholm, Secretary, California Water Service Co., San Francisco, Calif., in *Municipal News and Water Works*, while their accounts and records are carried under the California classification of accounts as prescribed by the commission. If the California commission could be persuaded to adopt the national association classification, it would, of course, result in considerable saving to their company.

Uniform Accounting.—Uniform accounting for water utilities can best be expressed through uniform classifications of accounts, but uniform classifications of accounts do not necessarily result in uniform accounting, as different accounts may classify items under entirely different heads. For this reason it is desirable that water utility officials get together for conference and in committees to iron out points of departure and arrive at an understanding as to just what each account heading shall include.

The following list of accounts was taken from the instruction book on Uniform System of Accounts for Water Utilities issued by the New Jersey Board of Public Utility Commissioners. This system follows the recommendations adopted by the National Association of Railroad and Utility Commissioners.

Water Utilities List of Accounts

BALANCE SHEET ACCOUNTS

ASSET ACCOUNTS

Fixed capital in water department
Fixed capital in other departments
Construction work in progress
Materials and supplies
Cash
Notes receivable
Accounts receivable
Interest and dividends receivable
Other current assets
Special deposits
Prepayments
Investments
Re-acquired securities
Sinking funds
Amortization fund
Other special funds
Unamortized debt discount and expense
Property abandoned
Other suspense
Corporate deficit

LIABILITY ACCOUNTS

Funded debt
Receiver's certificates
Notes payable
Advances from other corporations
Consumers' deposits
Other accounts payable
Unearned revenue
Taxes accrued
Interest accrued
Other accrued liabilities
Dividends declared
Other unfunded debt
Contributions for extensions
Amortization reserve
Contractual reserves
Unamortized premium on debt
Premium on capital stock
Casualty and insurance reserve
Miscellaneous reserves
Other unadjusted credits
Capital stock
Corporate surplus

FIXED CAPITAL ACCOUNTS

I. INTANGIBLE FIXED CAPITAL

Organization
Franchises
Other intangible capital

II. LANDED WATER CAPITAL

Water diversion rights
Reservation land
Other source of supply land
Purification system land
Pumping system land
Storage reservoir land
Other distribution system land
Miscellaneous landed capital

III. WATER COLLECTING SYSTEM

Reservation structures
Impounding reservoirs
Lake and river cribs
Springs and wells
Infiltration structures
Collecting reservoirs
Intakes and supply mains

IV. PURIFICATION SYSTEM

Settling basins
Coagulating basins
Softening and iron removal plant
Filters
Ozone sterilizing and aeration plant
Chemical treatment plant
Clear water basins

V. PUMPING SYSTEM

Hydraulic power structures
Pumping station structures
Boiler plant equipment
Steam power pumping equipment
Hydraulic power pumping equipment
Electric power pumping equipment
Other power pumping equipment
Miscellaneous pumping equipment

VI. DISTRIBUTION SYSTEM

Transmission mains and accessories
Storage reservoirs, tanks and standpipes
Distribution mains and accessories
Service pipes and stops
Meters, meter boxes and vaults
Fire hydrants and fire cisterns
Fountains, troughs and other equipment

VII. MISCELLANEOUS PROPERTIES

General structures
General equipment
Other tangible water capital

VIII. UNDISTRIBUTED CONSTRUCTION EXPENDITURES

Engineering and superintendence
Law expenditures during construction
Injuries and damages during construction
Taxes during construction
Interest during construction
Miscellaneous construction expenditures

INCOME ACCOUNTS

Operating revenues
Operating revenue deductions

NON-OPERATING REVENUES AND DEDUCTIONS

Rents accrued from lease of water plant
Miscellaneous rent revenues
Interest revenues
Dividend revenues
Miscellaneous non-operating revenues
Non-operating revenue deductions

INCOME DEDUCTIONS

Interest accrued on funded debt
Other interest deductions
Rent for lease of other water plant
Miscellaneous rent deductions
Amortization deductions
Miscellaneous deductions from income

APPROPRIATION ACCOUNTS

Miscellaneous credits to surplus
Expenses elsewhere unprovided for
Dividends on capital stock

Miscellaneous appropriations
Other deductions from surplus

OPERATING REVENUE ACCOUNTS

Metered private service
Unmetered private service
Service to other systems
Municipal hydrant service
Other muncipal service
Miscellaneous water service
Miscellaneous operating revenues

OPERATING EXPENSE ACCOUNTS

I. WATER COLLECTING EXPENSES

Collecting system expenses
  Collecting system wages
  (a) Collecting system superintendence
  (b) Collecting system labor
  Other collecting system expenses
Water purchased
Collecting system repairs
  (a) Repairs of reservations
  (b) Repairs of impounding reservoirs
  (c) Repairs of lake and river cribs
  (d) Repairs of springs and wells
  (e) Repairs of infiltration structures
  (f) Repairs of collecting reservoirs
  (g) Repairs of intakes and supply mains

II. PURIFICATION SYSTEM EXPENSES

Purification expenses
  Purification wages
  (a) Purification superintendence
  (b) Purification labor
  Purification supplies and expenses
Purification system repairs
  (a) Repairs of settling basins
  (b) Repairs of coagulating basins
  (c) Repairs of softening and iron removal plant
  (d) Repairs of filters
  (e) Repairs of ozone sterilizing and aeration plant
  (f) Repairs of chemical treatment plant
  (g) Repairs of clear water basins

III. PUMPING SYSTEM EXPENSES

Station wages
  Station superintendence
  Station labor
  (a) Boiler plant labor
  (b) Steam pumping labor
  (c) Hydraulic pumping labor
  (d) Electric pumping labor
  (e) Other pumping labor
  (f) General station labor
Fuel for power
  Steam pumping power
  Other power fuel
Power from other sources
  Steam pumping power
  Electric pumping power
  Other pumping power
Other pumping expenses
  (a) Water for steam or gas
  (b) Lubricants for pumping
  (c) Other station expenses
Pumping system repairs
  Repairs of hydraulic structures
  Repairs of station structures
  Repairs of pumping equipment
  (a) Boiler plant repairs
  (b) Steam pumping repairs
  (c) Hydraulic pumping repairs
  (d) Electric pumping repairs
  (e) Other power pumping repairs
  (f) Miscellaneous pumping repairs

IV. DISTRIBUTION SYSTEM EXPENSES

Distribution expenses
  Water storage and distribution
  (a) Distribution superintendence
  (b) Storage reservoir labor
  (c) Other distribution labor
  (d) Other distribution expenses
  Work on consumers' premises
  (a) Consumers' meter expenses
  (b) Consumers' installation expenses
Distribution system repairs
  Repairs of storage reservoirs
  Repairs of mains and accessories
  (a) Repairs of transmission mains
  (b) Repairs of distribution mains
  (c) Repairs of consumers' services
  (d) Repairs of fire hydrants and cisterns
  (e) Miscellaneous distribution repairs
  Repairs of consumers' meters

V. COMMERCIAL AND NEW BUSINESS EXPENSES

Commercial expenses
  (a) Commercial office salaries
  (b) Meter reading and collecting
  (c) Other commercial expenses
Business promotion
  (a) Promotion salaries
  (b) Promotion expenses

VI. GENERAL AND MISCELLANEOUS EXPENSES

Administration expenses
  Salaries of general officers
  Other general office salaries
  General office supplies and expenses
Law expenses
Injuries and damages
Insurance
Relief department and pensions
Water franchise requirements
Regulatory commission expenses
Store and transportation expenses
  (a) Store expenses
  (b) Transportation expenses
Miscellaneous general expenses
Miscellaneous adjustments—balance
  (a) Undistributed adjustments—balance
  (b) Duplicate water charges—Cr.
  (c) Water expenses transferred—Cr.
  (d) Joint operating expenses—Cr.
Repairs of general structures
General amortization
Taxes
Uncollectible water bills

Billing and Collecting Methods in a Small City

W. D. McKay, secretary, Water and Light Department, Brainerd, Minn., explains system in article for *Municipal News and Water Works.*

Some six years ago or more I introduced at Brainerd, Minn., a system which has worked very satisfactorily. It saves the expense of mailing bills to our customers, and in addition gives them the amount of their bills, as soon as meter is read.

The city has both water and light plants, and both meters are read at the same time, which is done monthly. There are about 5,000 meters, and two readers require about 21 days each month to read them. Our city is 100 per cent metered.

Blank No. 1 is used by the readers, and is filled out at

Water and Light Department

CITY OF BRAINERD

Telephone 66

Date of Reading_____ 192

Present this at the Office of the Secretary when payment is made.
Office Hours: 8 A. M. to 5 P. M. except
Paydays, when Office is open to 8 P. M.

Name_____

Street and Number_____

METER READINGS

Class	Readings	Consumption	Amount Dollars	Amount Cts.
Light	Present Previous			
Water	Present Previous			
Heat	Present Previous			
Power	Present Previous			
Sprinkling	Present Previous			
		Total		

NOTICE

Rules and Regulations for Customers

All rentals are due and payable at the office of the Secretary before 20th day of month following reading.

If rentals are not paid when due, a penalty of 10 per cent will be added and the city reserves the right to discontinue service without furher notice.

Parties moving into premises must report at once to the office of the Secretary, so that meter readings can be taken, and also ascertain whether previous month's rent has been paid, otherwise they will be held liable for said rent.

It will be appreciated if Office is notified of any leaks in streets or of any Arc Lights out of Commission.

Rules and regulations governing the system are printed and a copy will be furnished on application if you have none.

Blank No. 1

Schedule of Water Rates

All consumers up to 40,000 Gals, 50c per 1,000 Gals. From 40,000 Gals. up to 100,000 Gals. $20.00 per month minimum.
Over 100,000 up to 199,000 Gals. per month, 18c per 1,000 Gals.
Over 199,000 up to 299,000 Gals. per month, 14c per 1,000 Gals.
Over 299,000 up to 399,000 Gals. per month, 10c per 1,000 Gals.
Over 399,000 up to 700,000 Gals. per month, 8c per 1,000 Gals.
Minimum, 75 cents per month.

Sprinkling Rates

Sprinkling rates are governed by the April reading, and run continuously for five months. All used during this time in excess of April reading will be 10c per 1,000 Gals. Minimum of 1,500 Gals. per month for 75c. Sprinkling only applies beyond consumption of 1,500 Gals.

Electricity Rates

Light 6½ cents per K.W.H.
Power—First 500 K.W.H., 4 cents per K.W.H.
Bower—Next 250 K.W.H., 3½ cents per K.W.H.
Power—All over 750 K.W.H., 3 cents per K.W.H.
Cooking—3 cents per K.W.H.
Minimum for Light, 75 cents per month.
Minimum for Cooking, $1.00 per month.

Minimum on Power

$1.00 per H.P or fraction thereof up to 5 H.P 25c per H.P or fraction for all over 5 H.P

Back of Blank No. 1

ORIGINAL

Water & Light Dept. № 9107
CITY OF BRAINERD

Date of Reading.....8/22/28...192.
Present this at the Office of the Secretary when payment is made
Office Hours: 8 A. M. to 5 P. M., except Paydays,
when Office is open to 8 P. M.

Name ...J. Jones.....
Street and Number ....324 W 6thst .....
METER READING

CLASS		READINGS	CONSUMPTION	AMOUNT Dollars	Cts.
Light	Present	2647			
	Previous	3617	30	1	95
Water	Present	280000			
	Previous	276900	3100	1	55
Heat	Present	1552			
	Previous	1500	52	1	56
Power	Present	1000			
	Previous	260	740	10	40
Sprink'g	Present				
	Previous				
		Total		15	46
		Penalty		1	51
		Total			
		Adjustment			
		Total			
		Paid on Account			
		Balance			

Sample

NOTICE
Rules and Regulations for Customers

All rentals are due and payable at the office of the Secretary before 20th day of month following reading.
If rentals are not paid when due, a penalty of 10 per cent will be added and the city reserves the right to discontinue service without further notice.
Parties moving into premises must report at once to the office of the Secretary, so that meter readings can be taken, and also ascertain whether previous month's rent has been paid, otherwise they will be held liable for said rent.
It will be appreciated if Office is notified of any leaks in streets or of any Arc Lights out of Commission.
Rules and regulations governing the system are printed and a copy will be furnished on application if you have none.

Blank No. 2

once and left with the consumers. They have a ready table to make it from, thus avoiding errors. The meter books are audited before bills, as shown in Blank No. 2, are made out from them in duplicate. These bills are filed in a cabinet in street and numerical order, so that customers can be handled very promptly, as it simply requires stamping date of payment. One of these bills is original, the other a duplicate, with perforation between. They are not separated until payment is made. The duplicate is used for our Consumers' Register. Frequently before we used this system, claims would be made that the consumer had paid the previous month, but when we had the original that was evidence enough to know, without any further reference, it had not been paid. These duplicates are a great means also of determining our delinquencies readily, and aid very materially in our trial balances.

Reading water meters monthly enables us to keep in close touch with their condition, as we own all meters.

Municipal Water Department Accounting

The requirements for a municipal system was outlined in *Water Works* by W. C. Hail, senior municipal accountant, League of Kansas Municipalities, Lawrence, Kan. as follows:

The object of this article will be to present, in a general way, what may be considered the more important requirements of an adequate municipal water department accounting system. All forms suggested herein are subject to modification to meet local conditions or to meet the personal ideas of those in charge of the records.

Primarily a water department is interested in its actual cash receipts and expenses, for it is these items that determine the element of profit and loss. It is therefore apparent that the individual customer accounts and other cash transactions should be recorded through separate ledgers.

Customer's Ledger.—The customer's ledger account form, when properly designed, will carry the following information:

Meter readings by month; amount used; charges; arrears; penalty-discount; amount due; date paid and amount paid. It should also carry the customer's name, address and account number, as well as a meter description (meter number, make, size and location).

A meter reader reports the readings, usually by routes covering a given district. The meter slips should cover a year period, showing the present and previous month's reading; the customer's name; his address and the account number. From this slip the bill is made out on a coupon receipt card. Such cards are then set up in numerical account number order and are posted to the customer's ledger record.

Subsidiary Deposit Ledger.—A majority of utilities operating in Kansas require a meter deposit as a guarantee of prompt payment of bills. A subsidiary customer's deposit ledger should be carried, showing on the debit side, the account number, the name and address of depositor, date and amount of deposit received. On the credit side should be shown the date and amount of refund.

Service rendered by the water department to other city departments, such as fire hydrant service, water furnished to flush sewer lines, water supplied for city parks, swimming pools, etc., should be paid for by transfer from proper revenue funds to the utility. Cash receipts from water sales, meter deposits, and their sources should be entered through the ledger accounts suggested, to a distribution cash collection register.

Distribution Ledger.—A well-designed distribution ledger will provide for necessary classifications of receipts and disbursements. The disbursement side should be designed to serve as a warrant register. This ledger may carry any number of account numbers desired. As the volume of business increases there is a general tendency to increase the account numbers, and if this is carried too far, there is danger of swamping the records with details. However, thoroughness and completeness should not be sacrificed in the desire for simplicity. Such classifications of receipts and disbursements should be closed into a general ledger account.

Other ledger accounts necessary for a water department, include: Asset account, liability account, and a reserve for depreciation. These accounts are needed in making up the balance sheet which reflects the true financial condition of the plant.

The asset account includes:

Current Assets

Cash
Accounts receivable

Capital Assets

Real estate
Buildings
Plant machinery and equipment
Wells, pumps and motors
Transmission line
Reservoirs
Service line mains
Meters and meter installations
Fire hydrants
Supplies in warehouse
Other equipment

The liability account includes:

Accounts payable
Waterworks bonds
Reserve for depreciation
Reserve for meter deposits

The cost of furnishing water may be generally grouped as follows:

General Expense

Salaries of superintendent and inspector
Salaries of bookkeepers
Printing and office supplies
Telephone, express, postage
Insurance
Miscellaneous

Operating Expense

Pump and plant wages
Fuel
Oil, waste, packing
Chemicals
Miscellaneous

Distribution and Maintenance

Wages of outside men
Maintenance of high or low pressure stations
Maintenance of distribution system
Maintenance and miscellaneous equipment
Automobile expense
Small tools and repairs

Capital Outlays and Depreciation

Expansions and extensions
Pumping and purifying plants
Mains and hydrants
Meters and meter supplies
Lands and buildings
General equipment
Reserve for depreciation

Production Data.—Production data is important and essential for rate making purposes. The following table is given to show the items used in making up a monthly statement:

Operating Cost for Month

Operation of pump plant
Distribution and maintenance
General expense
Bond interest
Depreciation of equipment

Production for Month

Total gallons pumped for master meter
Sold consumers
City buildings
Parks
Street sprinkling
Sewers
Total accounted for
Water not accounted for
Per cent loss

Cost Per Thousand Gallons Computed on Amount of Water Pumped

Operation
Distribution
General
Bond interest
Depreciation

Cost Per Thousand Gallons Computed on Amount of Water Accounted For

Operation
Distribution and maintenance
General
Bond interest
Depreciation

The importance of frequent reports should not be overlooked. The preparation and distribution of financial reports affords one of the most valuable opportunities connected with the work of an accounting officer. Officials preparing such reports must bear in mind that clearness, brevity, and completeness are essential elements.

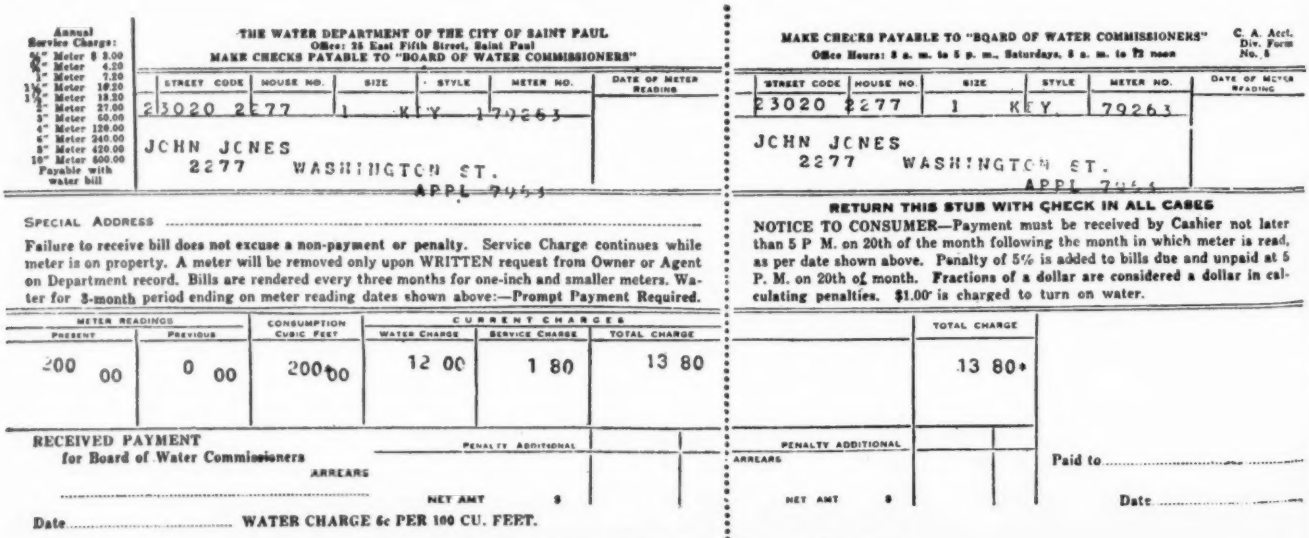
Accounting System for Large City

Methods of the St. Paul water department were described in *Water Works* by C. M. Crowley, registrar, water department, St. Paul, Minn., as follows:

Since Jan. 1, 1923, St. Paul's water department has been operated on the same plan as a private corporation managing a railroad or other utility, and its accounting system closely follows their best practice. Stores account, cost accounting, etc., and monthly and annual reports are issued and open to the public. The state public examiner audits the department in the same way as a county auditor or county treasurer's office, and requires up-to-date, safe and sound procedure in every division.

A brief account of the practice and methods in the revenue division may be of interest to some of your readers:

Accounting Methods.—Ninety-eight per cent of the active accounts are metered. All new supplies must be metered except automatic fire supplies. Meters 1 in. or less are designated as "domestic," 1¼ in. and over as "commercial." Domestic meters are read quarterly by dividing the city into three reading districts, reading and billing one district each month. Commercial meters are read and billed monthly. The meter rate is 6 ct. per 100 cu. ft. for all consumers. A monthly "service charge" is added to each bill according to the size of the meter while it remains on the property. Meters are removed only on request in writing by the owner or agent, and access given to property for removal. This avoids all dispute between the owner and the department, as 95 per cent of the requests are signed for an office record for shut off. A firm stand on



Annual Service Charge:
⅝" Meter $ 3.00
¾" Meter 4.20
1" Meter 7.20
1½" Meter 10.20
1¼" Meter 13.20
2" Meter 27.00
3" Meter 60.00
4" Meter 120.00
6" Meter 240.00
8" Meter 420.00
10" Meter 600.00
Payable with water bill

THE WATER DEPARTMENT OF THE CITY OF SAINT PAUL
Office: 26 East Fifth Street, Saint Paul
MAKE CHECKS PAYABLE TO "BOARD OF WATER COMMISSIONERS"

STREET CODE	HOUSE NO.	SIZE	STYLE	METER NO.	DATE OF METER READING
23020	2277	1	KEY	79263	

JOHN JONES
2277 WASHINGTON ST.
APPL 7465

SPECIAL ADDRESS .....

Failure to receive bill does not excuse a non-payment or penalty. Service Charge continues while meter is on property. A meter will be removed only upon WRITTEN request from Owner or Agent on Department record. Bills are rendered every three months for one-inch and smaller meters. Water for 3-month period ending on meter reading dates shown above:—Prompt Payment Required.

METER READINGS Present	METER READINGS Previous	CONSUMPTION Cubic Feet	CURRENT CHARGES Water Charge	CURRENT CHARGES Service Charge	CURRENT CHARGES Total Charge
200 00	0 00	200 00	12 00	1 80	13 80

RECEIVED PAYMENT
for Board of Water Commissioners

PENALTY	ADDITIONAL

ARREARS .....

NET AMT $

Date ..... WATER CHARGE 6c PER 100 CU. FEET.

MAKE CHECKS PAYABLE TO "BOARD OF WATER COMMISSIONERS"
Office Hours: 8 a. m. to 5 p. m., Saturdays, 8 a. m. to 12 noon
C. A. Acct. Div. Form No. 5

STREET CODE	HOUSE NO.	SIZE	STYLE	METER NO.	DATE OF METER READING
23020	2277	1	KEY	79263	

JOHN JONES
2277 WASHINGTON ST.
APPL 7465

RETURN THIS STUB WITH CHECK IN ALL CASES

NOTICE TO CONSUMER—Payment must be received by Cashier not later than 5 P. M. on 20th of the month following the month in which meter is read, as per date shown above. Penalty of 5% is added to bills due and unpaid at 5 P. M. on 20th of month. Fractions of a dollar are considered a dollar in calculating penalties. $1.00 is charged to turn on water.

TOTAL CHARGE
13 80

PENALTY	ADDITIONAL

ARREARS .....

NET AMT $

Paid to .....

Date .....

Fig. 1—Bill, 11x4½ In., Printed in Black on Yellow Paper

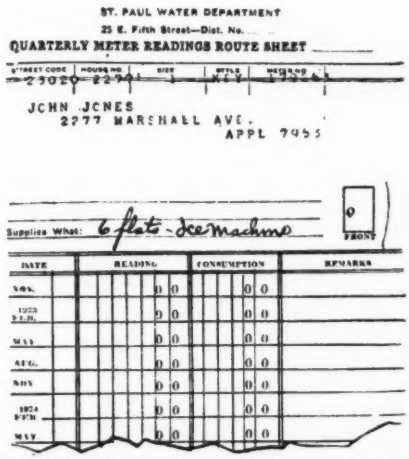


Fig. 2—Quarterly Meter Reading Route Sheet, 4½x8 In.; Printed in Black on White Paper; Ruled in Red and Blue and Perforated for Filing

this is very important in order to avoid disputes and consequent friction with the public. Experience has convinced the department that postponed disputes are the most aggravating. To settle it on the spot is the safest practice if at all possible. The water charge and service charge are itemized separately and consumers show closer attention to use and waste than they would under a minimum rate, which offers no reward for using less than the minimum charge. The minimum rate idea on metered water is therefore to a degree contradictory and naturally has ten-

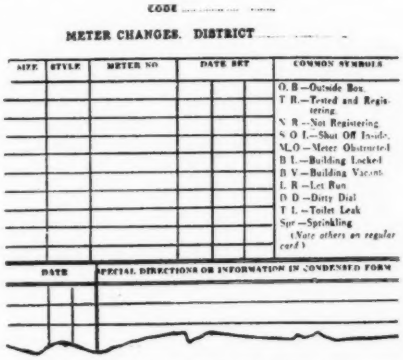


Fig. 3—Reverse of Fig. 2

dency to increase per capita consumption by small consumers, while the meter is installed to reduce it. The service charge seems to be the soundest practice.

Penalties.—Meter bills (Fig. 1) are penalized 5 per cent on each dollar or fraction of a dollar, if not paid on or before the 20th day of the month following meter reading, as shown on bill. As each day's exact receipts are deposited with the city treasurer the following morning, bills not reaching the cashier at closing time are returned without exception, unless penalty is included.

Meter Reading.—Meter reading sheets (Fig. 2) run from 2 to 6 years and carry a notation indicating what each supplies (with corresponding notation on ledger). The reader checks consumption with previous reading, and if high reading is sustained inspects for leak or cause of excess and notes same on reading sheet. He also leaves written notice to repair on property, with carbon copy returned to office. The consumer being caught red-handed, has no excuse and comes into the office with notice of repair and an apology instead of a kick, thus sparing the "kick clerk" and official staff much loss of time and criticism and friction. When the consumer is convinced that all are treated alike, he grins and bears it.

The department furnishes the meter and stands wear and tear, but hot water and frost damage is paid for by property. The reverse side of the reading sheets show meter changes and space for special notation. (Fig. 3.)

We trial balance about 60,000 accounts of all kinds in from 2½ to 3 days. We are prepared for audit on a moment's notice, or without it.

Meter Ledgers.—The meter ledgers (Fig. 4) show serial number of street service, reading district, size, style and number of meter, size of street service, owner of property and official street number, special address, monthly service charge and character of supply.

The ledger clerk compares the consumption with previous charges and above records and makes charge on an Underwood bookkeeping machine with a proof record, laying aside bills requiring further information, or noting prorate charges as the case requires. The corresponding bills are turned over to bill clerk with reading book. The bill clerk carries a schedule on his machine showing as follows: "Present Reading," "Old Reading," "Consumption," "Water Charge," "Service Charge," "Total." His schedule is then compared with the ledger clerk's tally roll and if they agree the books are in balance, the significance of which will be readily appreciated by department officers in charge of accounting involving a trial balance. Accuracy of subtractions and additions is attested by a star in all cases. Completed schedules, therefore, show total consumption total water charge, total service charge, total of all charges, for each ledger. The control clerk takes these schedules, which show name of clerk and ledger number, and charges each ledger with total amount of days charges, with a similar practice for the day's receipts. The trial balance taken by the ledger clerks must agree with the control.

One entry clerk enters all cash payments in skeleton except where checks are received. In case of N. S. F. check or involved payment we find this practice a sound one for public accounting, as it places a check on cash beyond dispute. Cash coupons are again separated by ledgers and scheduled and posted by machine proving totals. Stubs are kept two years on advice of city comptroller and public examiner for audit purposes—if necessary.

Changing readers on routes and a separate reader on disputed bills does away with all chance of curb reading, as we keep an efficiency record with each. For 1924 a total of 36 errors is quite a satisfactory record in view of the fact that quite a district of the city is subject to spring overflows, clouding meter dials, etc., and with only 110 service pipes to the mile of main.

A straight 6 ct. rate enables us to prove the charge by the consumption. A step rate would not be so satisfactory in that regard. Our dual system may seem overelaborate,

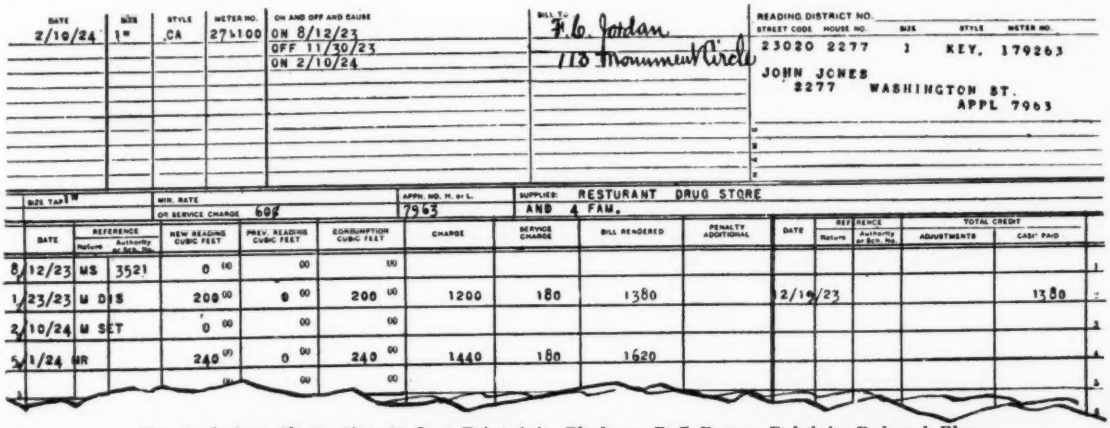


Fig. 4—Ledger Sheet, 12½x10 In.; Printed in Black on Buff Paper; Ruled in Red and Blue

but in public accounting, with every consumer a critic and having a right to examine the record, peace of mind and the satisfaction of leaving a clear record justifies the little extra effort required. Even at the peak hour of the last day for avoiding penalty our small office lobby rarely shows 30 people. Machine accounting has been a great assistance in improving a good system previously in practice. Limited vault space and fire risk induced the department to install a very satisfactory all-steel roll-top desk, with lock, for ledger cards. A code system is used to designate ledger accounts by numbering the alphabet, with street in the order of their installation in ledger, the house number constituting the ledger page, thus:

23020-2277 (Washington Ave. W.)
John Jones.

The bookkeeping machines used in this accounting system were furnished by the Underwood Typewriter Co. and the listing machines by Burroughs Adding Machine Co.

Use of Machines in Water Works Accounting

The following description of the use of machines in water works accounting was given by G. P. Moore, Jackson, Miss., in Water Works.

Four general plans for handling consumers' accounting work are:

Stub Plan
Register Sheet Plan
Ledger and Bill Plan
Dual Plan

The Stub Plan.—The stub plan, inasmuch as it seems to be the most popular of the present systems, will be discussed first.

We find some stub plans show more information on the ledger stub than others. One form may show only the current and past due charges. Another may show the consumption and amount due. Still others contain a record of meter reading, consumption and amount due. In this latter instance the additional stub or ledger record becomes an individual monthly ledger showing all the information formerly appearing in the old fashioned bound ledgers.

Credit posting methods for stub plans varies with the different users, although it is the general practice to perform this operation by the process of matching the paid cashier's or auditor's coupon with the ledger stub, separating the paid ledger stubs from the unpaids.

Some users then permanently bind the ledger stubs together. Others simply file the paid stubs separately from the unpaids. Either the right or left corner may be cut off or the ledger stub stamped paid as evidence of payment.

This credit posting operation may be performed every day or the paid cashier's stubs allowed to accumulate until after the expiration of the due, penalty or discount date, when they are then posted as one operation.

The Register Sheet Plan.—The register sheet plan gets its name from the use of the register sheet, made by the machine at the time the bill is prepared, as the consumer's ledger record. This plan has been popular in certain European countries for years.

There may be from 25 to 40 different consumers' records for the current month on each individual register sheet. Opposite the copy of the bill rendered is placed either the name and address on the account number of that particular customer. Arrears, additional charges or adjustments are also posted to this sheet next to the current amount column.

Credit posting is by machine, rubber dater stamp method or pen and ink.

Cash may be posted either daily or immediately after due, penalty or discount date.

The Ledger and Bill Plan.—The ledger and bill plan provides an individual continuous consumer's ledger card or sheet, which is debit posted at the time the bill is prepared.

The dual plan gets its name from the method of preparing the bill as a separate operation from debit posting the ledger.

Application of Machines.—In considering the application of machines to consumers' accounting problems, it should be thoroughly understood that no matter what type of plan is decided upon the machine operations can be simplified and speeded up by making use of the following desirable features now available.

(a) Automatic cross tabulating carriage.

This device automatically tabulates the carriage after each operation of the machine and returns the carriage to first position after the posting in the last position has been made.

(b) Automatic repeat print.

This device automatically repeat prints the items, entered on the bill, as original entries on both ledger and cashier's stub, thereby eliminating the use of carbon records.

(c) Automatic line finder.

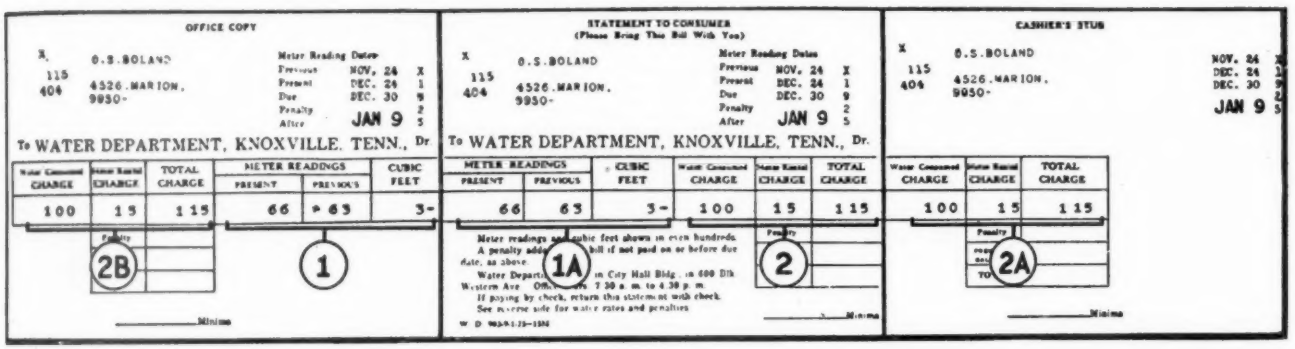
This device causes the bill and ledger to fall into pre-determined writing position without any effort on the part of the operator.

(d) Automatic opening of throat.

This device automatically causes the carriage platen to release the bill and ledger at the completion of each bill for easy removal and the insertion of the next consumer's record.

(e) Writing of bill, cashier's stub, ledger and sales recap sheet at one operation.

(f) Automatic accumulation of de-



How Burroughs Public Utility Machine Is Used by Knoxville, Tenn., for Writing Water Bill, Ledger Stub and Sales Recap in One Operation

Chutes for bill with adjustable tables for locating the printing line, are provided on machine carriage permitting easy insertion of bill to the desired position.

(1) The operator sets up in the keyboard the present and previous readings and the consumption, printing on the ledger stub of the bill, the carriage automatically moving forward to (1a)

(1A) An automatic repeat print of (1) on bill copying through to recap, the carriage automatically moving forward to (2)

(2) The water charge, meter rental and total charges are now placed in the keyboard printing on the bill and copied through to the recap, the carriage automatically moving forward to (2a)

(2A) An automatic repeat print of (2) on the cashier's stub

(2B) An automatic repeat print of (2) on the ledger stub, the carriage automatically tabulating to position (1) ready for posting of next bill.

The machine automatically accumulates the six desired totals on the recap.

sired totals for easy proof of billing and debit posting as well as for revenue purposes.

How the Machine Works.—The application of the machine embodying all of these desirable characteristics, together with its operation, will be briefly outlined:

It is a well known fact that water meters may get out of adjustment, due to dirt, chemicals in the water, freezing, etc. This makes it necessary to keep a careful check on the condition of the water meter as reflected by the meter readings.

The meter reader's book should be turned over to the checker, as soon as readings have been made, so that the consumption can be entered on the meter read sheet and checked for the condition of the meter.

Assuming that we are in the billing department of a water works, we will just visualize the machine operation:

The operator seated before the machine has her work arranged in the following manner: To the left on the check table is located the meter read sheet. Just in back of the meter read sheet is the billing chart. To the right of the operator is a bill holder from which the magazine in the bill chute is replenished.

The sales recap sheet with carbon over it is placed around the carriage platen to record from 50 to 100 bills.

The bill is dropped into the bill chute, falling into writing position without adjustment by operator.

The carriage release bail is touched, bringing the bill and sales recap sheet into printing position.

The operator then obtains from the meter read sheet the present and previous readings, together with the consumption and prints these three sets of figures by depressing the proper keys and the motor bar.

The machine prints this information on the ledger stub, automatically tabulating and repeat printing the same three sets of figures on the bill, carbon copying on the sales recap sheet, accumulating three separate sets of totals in the lower adding machine and again automatically tabulating to the next position on the bill.

While the machine is performing these mechanical operations the operator is obtaining from the billing chart the consumed charge, the meter rental charge and the total charge to be billed.

As soon as the machine stops in position two (2), the operator is ready to enter these three sets of figures by depressing the proper keys and motor bar.

The machine prints these three sets of figures on the bill, cashier's stub, ledger and sales recap sheet, accumulating three separate sets of totals in the upper counter of the machine, automatically repeat printing, tabulating, returning to position one, releasing the completed bill ready for easy removal.

Thus it is readily seen that with two simple keyboard setups the operator writes a complete line across the bill, cashier's stub, ledger and sales recap sheet at one operation.

The six sets of totals automatically accumulated by the machine are cleared out on the bottom of the sales recap sheet at the completion of the unit run of from fifty to one hundred bills.

Proof of the accuracy of the bills is obtained as follows:

The totals of the consumption and previous reading columns must agree with the total shown under the present reading column.

The consumption for other than minimum bills is multiplied by the rate. This total plus the minimum bills must equal the total shown under the water consumed charge column.

The totals of the water consumed charge and the meter rental charge must equal to the total shown under the total charge column.

Contents of Tanks and Cisterns Per Foot of Depth

From U. S. Cast Iron Pipe & Foundry Co.

Diam.	Area	Gals.	Diam.	Area	Gals.	Diam.	Area	Gals.
Ft. In.	Sq. Ft.	1 Foot Depth	Ft. In.	Sq. Ft.	1 Foot Depth	Ft. In.	Sq. Ft.	1 Foot Depth
4— 0	12.57	94.00	10—3	82.52	617.26	20—3	322.06	2409.2
4— 1	13.10	97.96	10—6	86.59	647.74	20—6	330.06	2469.1
4— 2	13.64	102.00	10—9	90.76	678.95	20—9	338.16	2529.6
4— 3	14.19	106.12	11—0	95.03	710.90	21—0	346.36	2591.0
4— 4	14.75	110.32	11—3	99.40	743.58	21—3	354.66	2653.0
4— 5	15.32	114.61	11—6	103.87	776.99	21—6	363.05	2715.8
4— 6	15.90	118.97	11—9	108.43	811.14	21—9	371.54	2779.3
4— 7	16.50	123.42	12—0	113.10	846.03	22—0	380.13	2843.6
4— 8	17.10	127.95	12—3	117.86	881.65	22—3	388.82	2908.6
4— 9	17.72	132.56	12—6	122.72	918.00	22—6	397.61	2974.3
4—10	18.35	137.25	12—9	127.68	955.09	22—9	406.49	3040.8
4—11	18.99	142.02	13—0	132.73	992.91	23—0	415.48	3108.0
5— 0	19.63	146.88	13—3	137.89	1031.5	23—3	424.56	3175.9
5— 1	20.29	151.82	13—6	143.14	1070.8	23—6	433.74	3244.6
5— 2	20.97	156.83	13—9	148.49	1110.8	23—9	443.01	3314.0
5— 3	21.65	161.93	14—0	153.94	1151.5	24—0	452.39	3384.1
5— 4	22.34	167.12	14—3	159.48	1193.0	24—3	461.86	3455.0
5— 5	23.04	172.38	14—6	165.13	1235.3	24—6	471.44	3526.6
5— 6	23.76	177.72	14—9	170.87	1278.2	24—9	481.11	3598.9
5— 7	24.48	183.15	15—0	176.71	1321.9	25—0	490.87	3672.0
5— 8	25.22	188.66	15—3	182.65	1366.4	25—3	500.74	3745.8
5— 9	25.97	194.25	15—6	188.69	1411.5	25—6	510.71	3820.3
5—10	26.73	199.92	15—9	194.83	1457.4	25—9	520.77	3895.6
5—11	27.49	205.67	16—0	201.06	1504.1	26—0	530.93	3971.6
6— 0	28.27	211.51	16—3	207.39	1551.4	26—3	541.19	4048.4
6— 3	30.68	229.50	16—6	213.82	1599.5	26—6	551.55	4125.9
6— 6	33.18	248.23	16—9	220.35	1648.4	26—9	562.00	4204.1
6— 9	35.78	267.69	17—0	226.98	1697.9	27—0	572.56	4283.0
7— 0	38.48	287.88	17—3	233.71	1748.2	27—3	583.21	4362.7
7— 3	41.28	308.81	17—6	240.53	1799.3	27—6	593.96	4443.1
7— 6	44.18	330.48	17—9	247.45	1851.1	27—9	604.81	4524.3
7— 9	47.17	352.88	18—0	254.47	1903.6	28—0	615.75	4606.2
8— 0	50.27	376.01	18—3	261.59	1956.8	28—3	626.80	4688.8
8— 3	53.46	399.88	18—6	268.80	2010.8	28—6	637.94	4772.1
8— 6	56.75	424.48	18—9	276.12	2065.5	28—9	649.18	4856.2
8— 9	60.13	449.82	19—0	283.53	2120.9	29—0	660.52	4941.0
9— 0	63.62	475.89	19—3	291.04	2177.1	29—3	671.96	5026.6
9— 3	67.20	502.70	19—6	298.65	2234.0	29—6	683.49	5112.9
9— 6	70.88	530.24	19—9	306.35	2291.7	29—9	695.13	5199.9
9— 9	74.66	558.51	20—0	314.16	2350.1	30—0	706.86	5287.7
10— 0	78.54	587.52	.....	.....	.....	.....	.....	.....

R. D. COLE MANUFACTURING CO.

ESTABLISHED 1854

Newnan, Ga.

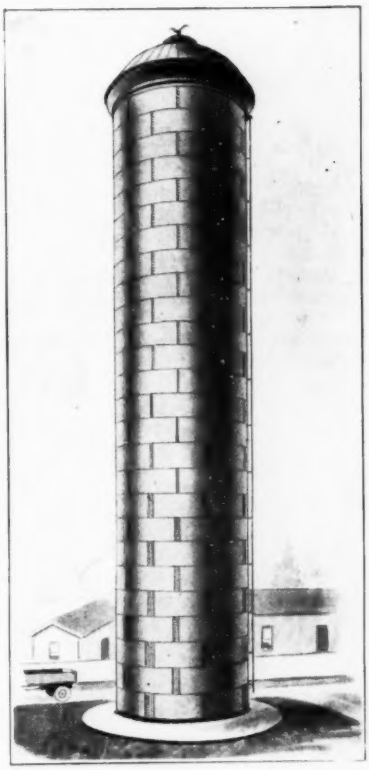
Tanks, Boilers and Steel Plate Work

BRANCH OFFICE: 5 BEEKMAN ST., NEW YORK CITY

Products: STEEL TANKS, STAND PIPES, ELEVATED TANKS, STEEL STACKS, GAS TANKS, GAS HOLDERS.

Horizontal Return Tubular Boilers: Constructed in a most approved manner and of materials in full accordance with the A. S. M. E. Code.

Standard settings can be provided with stationary or shaking grates, and where increased efficiency and compactness are desired standard steel casings can be provided for these settings.



Steel Tanks, Towers and Standpipes: This company designs, fabricates and erects steel tanks and towers for sprinkler or general service, also standpipes.

Cole elevated tanks are correct in design. Their simplicity contributes to their low cost of maintenance. Sprinkler tanks and equipment are designed to incorporate the recommendations of all insurance authorities.

This company has been building tanks, towers and standpipes for over thirty years and its exceptional facilities, together with its large force of tank experts, insure reliable work and prompt delivery.

Steel Plate Construction: The facilities of the R. D. Cole Manufacturing Company provides for the design and construction of all forms of steel plate work, including smokestacks, acid and pressure tanks, structural frames and towers, etc.

A large and experienced engineering department is at the service of prospective customers to assist on solving their problems.

Water Waste Surveys

The methods used at Ottawa, Ont., for locating leakage were described as follows by A. D. Stalker, Engineer, Waste Detcetion Branch, Works Department, Ottawa, Ont., in *Water Works*:

Waste control, as a subject, can be divided very conveniently into two parts: First, that having to do with wastage which takes place inside houses and other buildings; and second, that concerned with wastage from the underground portion of the distribution system.

Causes of Waste.—The wastage which takes place inside buildings is caused largely by defective plumbing fixtures, and by carelessness. In cities and towns that have very warm weather in summer and very cold weather in winter, a great deal of water is wasted in lawn sprinkling in the first instance, and to prevent freezing in the second. I use the word "wasted" advisedly.

It is perfectly true that well-kept lawns add to the attractiveness of a city to an extent that makes them well worth the cost of the water necessary to keep them in good condition. Water used intelligently for this purpose cannot properly be considered waste. The trouble lies in the fact that unfortunately water is not always intelligently used for this purpose.

There is certainly no necessity for having lawn sprinklers running during a storm, yet this is something that quite frequently happens. The amount of water used for lawn sprinkling can be materially reduced by having a by-law stating certain off-peak hours during which sprinkling is allowed, and providing penalties for sprinkling at any other time. The effectiveness of such a by-law will depend almost entirely on the extent to which it is enforced.

The running of water to prevent freezing should be prohibited. Plumbing by-laws should be so framed as to insist on the pipes leading from the main to the house being laid below the frost line, and on the piping inside the building being kept away from exterior walls, and installed in such a manner as to remove the danger of freezing.

Meterage As a Remedy.—By far the most effective method of dealing with the wastage that takes place inside buildings is by having services 100 per cent metered. The person who has to pay for water through a meter can generally be depended upon to be economical in its use. To make the watertaker pay for the water he wastes, will reduce that waste to a minimum.

In cities or towns where none, or only a small percentage of the services are metered, the control of waste from defective plumbing fixtures is much more difficult. Systematic house-to-house inspection, regularly maintained by a permanent staff of inspectors, will prove a great aid in keeping this class of waste within reasonable bounds. These inspections must be frequently repeated, and to be effective must be supported by strong laws and good plumbing ordinances.

In Ottawa when defects in plumbing fixtures are located by any one of the inspectors, the owner of the property is given 48 hours in which to make the necessary repairs. The inspector re-examines the premises at the expiration of the 48 hours, and if repairs have not been made, the service is shut off, and before it is again turned on repairs must be effected, and the owner is compelled to pay the sum of $1.00 as a charge for the services of the turnkey.

The water that is wasted as the result of pure carelessness is probably as difficult a class of waste to deal with as any. Educational campaigns and public appeals, while no doubt effective in the face of actual or impending water famine, do not seem to be impressibly effective where no such famine, or threat of famine, exists.

So long as the source from which the water is drawn is ample for the community's needs, the public seems to labor under the delusion that in some mysterious way the whole supply is available for use without the expenditure of either money or labor.

Our public also seems to think that the information contained in educational literature dealing with the importance of attending to small leaks and wastes should make a great impression—on somebody else. The value of this type of waste-control work is debatable. The writer's opinion is that the results obtained are not worth the trouble and expense of getting up and distributing the literature. The only cure for waste due to carelessness is metering.

The Pitometer.—The second phase of waste reduction has to do with the location of leakage from the underground portion of the distribution system. To find the leaky parts of the underground system, a survey must be made to ascertain where the water goes after leaving the pumps, and what parts of the system receive excessive quantities. This can be accomplished by means of a pitometer.

The pitometer is an instrument that adapts the "Pitot" principle to the measurement of water. Two tubes enclosed within a metallic sheath are introduced into a water main through a 1-in. corporation cock. The tubes are set in such a position that one orifice faces directly up-stream and the other directly down-stream. They are connected by means of rubber tubing to a glass U-tube containing a liquid of a specific gravity higher than water and which will not mix with it. The difference between the pressure on the downstream and on the upstream orifices, which is the pressure due to velocity, causes a deflection of the liquid in the arms of the U-tube, and from this deflection the flow is calculated.

The prism photo recording pitometer makes a continuous photograph of the U-tube fluctuations upon a sheet of sensitized paper attached to a drum revolved by clock-work. The drum can be geared to complete a revolution in 12, 24 or 48 hours. From this photo record the flow through the main can be ascertained for any time during the gauging.

To measure accurately the flow through mains with the pitometer, the ratio of the mean velocity to the center volocity must be established, as the orifices of the instrument are set at the center. This ratio is called the "pipe co-efficient" and is established by traversing the pipe. A pipe traverse is made by taking readings of the velocity at intervals across the pipe sufficiently close together to make a smooth curve when plotted. The pipe section is divided into rings of approximately the same area. The mean velocity of each ring in feet per second multiplied by the area of the ring in square feet, gives the ring volume in cubic feet per second. The mean velocity for the whole pipe section is the total of these ring volumes divided by the area of the pipe. The mean velocity divided by the center velocity is the pipe co-efficient. On large mains it is desirable to traverse the pipe on two diameters 90 degrees apart and in the same plane. By using two rod meters, one can be left at the center of the pipe and the traversing done with the second, and readings taken when the center velocity is the same in each case. The pipe co-efficient is the same for all velocities in the same pipe at any particular point, and it is upon the discovery of this principle that all pitometer gaugings are based.

How Pitometer Survey Is Made.—A pitometer survey should properly start at the pumping stations, and the discharge from the pump checked. When this has been done, I think it good practice to test all trunk or feeder mains before dividing the system into districts. These mains taken separately can be quickly done, and the distribution of water through that part of the system fed by them is interfered with for a much shorter time than would be the case if they were to form part of a district. Furthermore, trunk mains are usually so spaced as to form excellent district boundaries.

More accurate results can be obtained if the pitometer tap is placed on a small main feeding into the trunk main than would be the case if the tap were to be placed on the trunk main itself, as a flow that would cause scarcely any deflection of the liquid in the U-tube if the tap were on the large main, would cause a sufficiently great deflection to give an accurate measurement of the flow if the tap were on the smaller main. The tap may be placed in such a position as to serve as a gauging point both for the trunk main and one of the districts.

The next step is the dividing of the system into districts. This work must receive careful consideration. A district should be of a size that can be conveniently sub-divided in one night during the hours of minimum consumption, and the boundaries laid out with a view to causing as little interference as possible with the circulation through the balance of the system. The gauging point should be on a main of such a size that a velocity of about 4 ft. per sec. would supply the maximum normal demands of the district, without any allowance for leakage. This velocity will give a deflection of about 17 in. on the U-tube, using a liquid of 1.25 specific gravity. The maximum consumption would not be likely to cause a velocity great enough to blow the liquid out of the tube, and the minimum consumption would

cause a fairly high deflection. When the district is first gauged, a velocity higher than the above will probably be recorded, and a heavier liquid might have to be used. The idea behind choosing a main of this size is to ensure a deflection high enough to give an accurate measurement of the flow when all leaks have been stopped.

It is necessary that those entrusted with waste reduction should become thoroughly acquainted with the conditions that exist in the various districts. The population and how it is distributed, and whether the area is industrial or residential, must be known in order to determine what quantity of water would be sufficient for its needs.

If the survey being made is an original one, a 48 hour record should be taken, including a Sunday if possible. Very careful records should be kept of all flows recorded and work done, and of any peculiar or unusual conditions that may be found to exist, as this information will, without doubt, be of great assistant in later surveys. Weather conditions and any circumstances which might affect the consumption of water should be noted.

When the flow is to be gauged, the district is cut off from the rest of the distribution system by closing all the valves on the boundaries, excepting on the pipe to which the instrument is connected. To make sure that the valves are holding properly, and that no water is getting in, either through them or through services that may be joined up inside buildings and connected to mains on both sides of a boundary, the main feeding the area enclosed should be closed and a hydrant at the highest point within the boundaries opened. If the hydrant is not off, the point at which the water gets into the district must be located, and the flow stopped. When it is assured that the whole supply passes through the main to which the instrument is connected, the district is ready for the taking of the record. Precautions should be taken to prevent street flushers drawing water from hydrants located within the district boundaries while the record is being taken. It is advisable also, to have a man with a valve key stationed at a fire hall either in or convenient to the enclosed area, so that valves could be opened with as little delay as possible in the event of a fire breaking out. If a fire occurs in a district while the flow is being recorded, the record will be ruined, and opening the boundary valves cannot make it any worse.

If the record taken indicates that an excessive amount of water passes the gauging point, and that the flow remains high during the hours in which very little water would be used, the district should be sub-divided. For subdivision purposes the mechanism revolving the drum of the pitometer is geared to complete a revolution of the drum in twelve hours. This will give a movement of an eighth of an inch in five minutes.

One method of sub-dividing is to divide the whole district into sections as small as the spacing of the valves will permit, and then closing a section down for a short period (at least five minutes) and re-opening it, and repeating this operation with other sections, until all have been shut down. Another method is to start at the boundaries and work towards the instrument, gradually reducing the size of the district, and as the new boundary valves are closed, the old ones are opened. The method used will depend on the conditions that exist in the district. With either method, the time each shutdown is completed must be noted. It is important that all valve operations should be checked over before leaving the district, to make sure that no valves are left closed.

Locating the Leaks.—When the subdivision record has been interpreted we will know the quantity of water each section of the district received. The sections that receive excessive quantities should be carefully gone over and the reason for the large flow ascertained. It is a good idea to have a plumbing inspector make a special examination of the fixtures in all buildings in these areas. If this inspection fails to account for the flow, it is assumed that the cause is underground leakage.

There are a number of methods usually employed to give the exact location of underground leakage. The one most generally used, and the one by which a great majority of leaks are found, is by sounding. There are a number of instruments on the market devised to help in picking up sounds, and those that I have used have proven of great assistance. The procedure is to sound all the valves, hydrants and services in the suspected area, and sometimes it is possible to get closer to the source by driving rods down to the main. It is remarkable what an experienced man can accomplish by sounding. In a great many cases he can not only tell where the leak is, but its nature—whether it is a blown joint, a split main, or a burst service pipe.

There are, however, a number of cases in which the sounds picked up are confusing. Where there are two or more leaks close enough together for the sounds to overlap, it is difficult to isolate the sound from one leak and trace it to its source. Leaks that discharge under water produce a sound that is often misleading. Then there is the abandoned service that has not been properly blanked at the main, but beaten up at building end. This practice was much more prevalent in the past than it is at present, but the leaks resulting have not yet been all located. In places that have had fires that burned over large areas, many such services exist. Leaks on these services are difficult to locate, for they generally occur on the beaten end, and as lead is a poor conductor of sound, if any noise at all is picked up, it is too faint to be of much help. If this method of blanking services still persists anywhere, those responsible for the management of the water department in that place are letting themselves in for a lot of future trouble.

Other methods used in conjunction with sounding include testing the pressure at different points until the point of minimum pressure is located; noting the flow in sewers at the manholes; pounding the road surfaces to endeavor to locate cavities beneath the pavement, and searching in cellars and excavations for dampness.

If the above expedients fail to locate the leak, the primitive of digging is resorted to. It is quite probable that the first hole put down will not be in the right place, but from the conditions that exist at this point, a second hole is usually all that is necessary.

Water appearing any place should be looked on as a possible leak, if the reason for its appearance is not apparent. The following is offered as an illustration: Some years ago, this city had a serious epidemic of typhoid fever. Water from any source other than the city mains was in great demand. During this time the writer noticed people drawing water from what appeared to be a spring located at the bottom of a hill. Those familiar with the locality insisted that this spring had always been there, and the city had had a sewer installed to carry off the overflow from it. A sample of the water was analyzed and the analysis showing that the water was very similar to that supplied by the city, the area in the vicinity of the spring was examined. At the top of the hill a 2-in. service that had been installed some thirty odd years previously, was found to be running full bore. This was stopped and the "spring" immediately dried up.

Other Duties of Waste Reduction Department.—In addition to the work outlined above, it is the duty of the department in charge of waste reduction to attend to all cases of flooding of cellars. The first thing to be done in these cases is to find whether or not the water department is responsible. In most cases a test of the electrical conductivity of a sample of the water is sufficient to decide. If the result of this test is not conclusive, an analysis of the water is made, and if it shows that the water comes from the mains, the leak is located by one of the methods mentioned above.

When serious breaks occur in the distribution system they usually give plenty of surface indication as to their locality. These are attended to by the trouble department. Bad breaks do accur without giving such indication, however, and these are followed up by the waste-reduction department. In such cases, the department first gets in touch with all the fire halls in the city, each of which has a pressure gauge installed, to find if possible an area in which the pressure has dropped. If no indication is given in this way, men are sent out to go over those parts of the system where it would be possible for the water from such a break to escape without surface indication. To know where to send the men requires an intimate knowledge of subsurface conditions throughout the city. Pipes crossing waterways and mains in rocky sections through which large sewer or other excavations have been cut, should be sounded, and if the leak still remains unlocated, short readings of the flow to districts is resorted to.

Results Obtained in Ottawa.—In 1918 the consumption of water was 218 gal. per capital per day. In 1926 it had been reduced to 150 gal. This consumption is still too high—much too high. Our past experience, however, leads us to expect that it will be materially reduced in the future.

What Water Waste Survey Disclosed

The following article by H. E. Beckwith, District Manager, The Pitometer Co., New York, N. Y., appeared in *Municipal News and Water Works:*

It is by way of returning in small measure the helpful courtesies shown us by the men in the water works field that this article is written, and with the hope that they may find some helpful hints in the conditions we have found in other plants.

When the Valves Were Closed.—It is, of course, very common to find closed valves. Attention is called to two such instances: In the first of these an entire town of some 20,000 persons was being fed through four 6-in. mains, because a valve on the main 16-in. feed was closed. Moreover, this was the only valve in the entire system found closed, showing that care was taken to check up on the valves. Furthermore, and this is of special importance, it was the only geared valve in the system. When the operating nut on the gear was turned in a clockwise direction, the valve stem was turned counter-clockwise. As the valve stem on this valve closed in the same direction as all other valve stems in the system, it was necessary to turn the operating nut in the direction opposite to that of every other operating nut in order to close the valve. Someone failed to take this into consideration, with the result that the valve had been kept habitually closed.

In the second case, the hydraulic grade line was apparently lower at one point than it was at another point on the same line, ¾-mile further from the source of supply. This was on the system of a small company serving several miles of territory with laterals feeding directly off one long main, or rather, it had been one long main originally. For 1½ miles of its length it had later been paralleled with another main. This second main was tied to the original main at no place other than at its ends, and no laterals came off of it. A study was being made for the purpose of reinforcing the system. When the hydraulic gradient for the system, as determined in the field, was plotted on cross-section paper, it was found that midway between the ends of the two parallel mains the hydraulic grade line was lower than at either end. Subsequently, the valve on the reservoir end of the "old" main was found to be closed. All water being used along the mile and a half of parallel mains had to go to the farther end and then feed back toward the reservoir. Opening the closed valve, of course, took the sag out of the grade line and increased pressure below the point where the valve had been closed. The trouble in this case was caused by right and left-hand valves being indiscriminately sprinkled throughout the system. Volumes could be written about the trouble caused by indiscriminate use of both right and left-hand valves in the same system. This is merely another example of the results of this practice.

Why the Supply Main Delivered No Water.—Speaking of hydraulic gradients, there is the case of the city whose officials had believed their system was being fed by two mains from the reservoir. A pitometer test proved, however, that there was no flow through one of these pipes. Further investigation showed that this main at one point actually lay above the water level of the reservoir. After the line was lowered, its vacation was over and it went to work delivering water to the city.

Accounting for a 50 Per Cent Loss.—Another very interesting case was that of a city which had originally been served by two separate companies. Later, these companies were merged and the distribution system was interconnected. Each of these companies originally secured its water by gravity from a mountain reservoir, the reservoir of one company being 12 ft. higher than that of the other company. Since the complete metering of this system a few years ago the meters through which water was sold had accounted for a little less than 50 per cent of the water shown on the Venturi meters installed at the reservoirs. Our tests showed that during the night, when the use of water in the system dropped low, the water fed out of the higher reservoir into the lower. It is the nature of a Venturi meter to measure in a positive direction the water which goes through it, regardless of the direction of flow. Consequently, the water which fed from the higher to the lower reservoir was measured on each of the two Venturi meters, although as a matter of fact, it was never used in the distribution system at all. When the Venturi meters were originally installed the city was on a flat rate basis, and the waste of water was so large that it is doubtful if the water ever backed up into the lower reservoir. But with the metering of all the services the amount of waste gradually fell off until the condition prevailed of which I have just spoken.

Whenever a water system is fed by gravity from two or more reservoirs on different levels, it is well to grow immediately suspicious of back-feeding when the supply in the lower reservoir holds up better than the supply in the upper one.

Incorrect Meter Reading.—Another very interesting case was that of a small suburban city which purchased water from its larger neighbor by meter. As the city was being paid on its meters for less than half the water entering the distribution system, the water department had accumulated a large deficit. In addition to the conditions usually found by a survey, it was discovered that two 4-in. and two 6-in. meters were being incorrectly read, and that the city was being paid for only 10 per cent of the water going through them. The value of the water which had passed through the meters, but which had never been paid for, was nearly equal to the deficit of the department. An effort was made to collect this money on the grounds that the bills rendered the consumer bore the meter readings and his acceptance and payment of the bills constituted an acceptance of the correctness of the meter readings. As the department did not use a step rate, the matter of billing was comparatively simple. It is to be regretted that we cannot advise you as to the outcome of this attempt to collect, as we left the city before any settlements were made. Two of the consumers had, however, expressed a willingness to pay; and I understand that the state commission had ruled that any failure on the part of the city to collect the full amount would be equivalent to the granting of preferential rates and would therefore be contrary to law.

This under-reading was caused by the fact that the smallest dial on the meters involved was graduated in units of one hundred, whereas the smallest dial on all other meters on the system was graduated in units of ten. The meter reader entirely overlooked the necessity of investigating the meter to determine in what units it was graduated.

How to Prevent Inaccurate Meter Reading.—That this is not the only case of its kind is shown by the fact that another similar condition was recently found. As a remedy for this it is suggested that meter readers be not permitted to take their previous readings on a meter into the field and so help to carry the error through. It is further suggested that the office clerks be forbidden to change any readings in order to make them conform to previous readings. Wherever a doubt exists as to the accuracy of the reading on a large meter, it would be well to have it checked by the meter company's representative.

In another suburban city, which also purchased its water through a meter, periodically the receipts from the water department would drop below the cost of its water. The trouble in this case lay in a compound meter to a steel mill. The high duty side of this meter was dead; and whenever business was sufficiently good with the steel company to cause a draught of water large enough to throw the flow onto the high duty side of the meter, business was very bad with the water department. Another factory in a different part of the city had been suspected of stealing the water, which is probably the one reason why the real cause of this lost water was not discovered before.

In the same place, the larger city had metered two services, and had for years been collecting revenue from them, when, in reality, the services were attached to the mains of the smaller town. Both cities had mains in this one street. In this case, all moneys that had been so collected were turned over to the smaller town.

The Source of the Spring.—In another suburban borough which purchased water by meter, the newspapers stated that the leak discovered by the survey had been running for

twenty-five years and had cost the borough in that time a quarter of a million dollars. This is not of particular interest here, except as it lends point to another statement made by the same news article. It seems that, when a large sewer was laid past this leak, it was impossible to handle the water with a pump. It was decided that a spring had been tapped and special foundations were put in to protect the sewer. It should be noted here that the leak was from the open end of an abandoned service, of which the borough had no record. In view of the known heavy losses, it is certain that the leak would have been discovered when this sewer was laid, had the water come from the direction of the main and not from the direction of a vacant lot.

It is remarkable how many springs, and swamps even, dry up after leaks on the water system are repaired. And how many people lose their source of valuable medicinal water.

Unauthorized Uses of Water.—Several years ago, when the stock of privately owner water companies was more or less a drug on the market, and few companies had paid dividends in many, many years, we caused considerable consternation on the part of the president of one company where we were working. It developed that a certain manufacturing company in the city was getting about 100,000 gal. of water a day free, through a defective meter. The president of the water company was also president of this factory. It was bad enough, he felt, not to get any dividends on his water company stock, without having the dividends of his factory cut into by increased water bills.

In another case we were called in to locate the cause of a large amount of water escaping from the high pressure system of a middle sized city. By a quirk of fate, it was discovered that 300,000 gal. per day of water were being surreptitiously taken from the system by a plant which was largely the property of the water commissioner. And he was the man who had been most instrumental in securing the commission for us in the first place. Certain it was that this water was being taken without this knowledge.

As a matter of fact, we find it generally true that where water is being taken in an unauthorized manner, it is done without the knowledge or consent of the higher officials of the companies. It is usually some department head wants to take a short cut to a good showing for his department.

Low Pump Discharges.—In recent years there has been a rapid increase in the development of electric power, with the result that many water plants have found it economical to substitute electrically driven centrifugal pumps for the old steam plant. Unfortunately, a full realization of the limitations of this type of pumping unit does not seem to have accompanied its installation. In only too many cases the only requirement placed on the pump is that it pump water. No apparent consideration is given to the efficiency with which this work is done. The displacement type of pump allowed so much latitude in operating conditions that many plant operators have not yet come to a full realization that centrifugal pumps operate efficiently only under the design head, and at the design rate of discharge.

No branch of work being done by our firm is more interesting than the efficiency tests on electrically driven centrifugal pumps. In one instance the pumping units were two 2,500,000-gal. pumps, working in parallel to give a combined output of 5,000,000 gal. per day. These pumps were designed to work against a head of 100 lb. The time came when these pumps would not carry the maximum day load. So the output was increased by putting the discharge of these two pumps through a 5,000,000-gal. pump designed to pump against a head of 50 lb. This gave then, an installation designed to pump 5,000,000 gal. against a head of 150 lb., whereas it was working against a head of only 100 lb. This gave an increased rate of discharge, but at a considerable cost in efficiency. This was not the sole reason why the wire to water efficiency of the installation was under 44 per cent, as several pieces of wood were later taken from the ports of one of the pumps, but it did have a very important bearing on the loss of efficiency. It is of interest to add that, after disconnecting the 50-lb. pump from the discharge of the two 500,000-gal. pumps, and cleaning these latter out thoroughly, a subsequent test on these two pumps gave an over-all wire to water efficiency in excess of 70 per cent.

In another instance the clear well was of such small size that it was necessary to coordinate the flow from the filters into the clear well with the pumpage out of it. As the low lift pump from the river to the filters had a higher rate of discharge than had the pump from the clear well to the distribution system, this coordination between the two pumps was secured by partially closing a valve on the discharge of the low lift pump. This increased the head at the pump above its design head and induced a slip into it. So much was this increase in head and slip that the power required to pump the reduced flow was much more than would have been required to pump the greater quantity for which it had been designed, had it been operating under design conditions. Throttled down, the pump had an over-all efficiency of approximately 30 per cent. A new low lift installation designed for a discharge equal to that of the high lift pump, thereby eliminating the necessity for throttling, gave on test, an over-all efficiency of approximately 60 per cent.

Another city had been computing its pumpage on a false pump rating, a rating in fact about double the pump's actual capacity. This pump rating was so much in error that, had it been correct, the installation would have had a wire to water efficiency in excess of 100 per cent. And the secret of perpetual motion would at last have been found.

These cases are called to your attention in order to emphasize the necessity for the services of a reputable engineer when this type of installation is contemplated. With the decreasing cost of electricity, this installation is becoming increasingly popular. The efficiency of electrical units should be closedly watched. The greater efficiency being obtained from modern units will often be sufficient to warrant the installation of new equipment.

The speaker recalls one instance where the replacement of an old installation having an over-all efficiency of 57 per cent with a modern unit having an over-all efficiency of 72 per cent decreased each monthly power bill an amount equal to 5 per cent of the total cost of the new installation.

Then there was the centrifugal pump whose 10-in. discharge line was reduced to 6 in. for a few lengths of pipe. The explanation given for this novel procedure was that the water pressure would be increased after going through the smaller pipe. This reasoning sounds strange to us today, but one of our engineers, delving through the council records of a city where he was working, found a case equally interesting.

When Hydraulic Knowledge Was Limited.—Some sixty years ago when our knowledge of hydraulics was not as extensive as it is today, an engineer had been employed to design a main between the reservoir and the city. This main was partly 20 in. and partly 18 in., fed by a 12 in. from the reservoir. The engineer in charge of the work was the author of the following interesting explanation:

This main line of pipe was enlarged by the direction of the Committee on Water under the light head at the Westerly end, to render the same much more effective as a means of conveying and delivering water at the extreme end of the pipe here in the city. Since the lighter the head, the larger is the required diameter of the pipes necessary to furnish the amount of water conveyed by the small pipe under a much greater increase of head; this change has been one of much utility in increasing the efficiency of this supply main.

Within ten years after the main was put in service, the supply in the city became so deficient that the main was not full at all times. The report of the Water Committee says:

While the discussion was going on about the high service, the engineer discovered that the main pipe already laid was wrong end first, and that the advantages of having a small pipe near the reservoir to fill and supply a larger one in the city, were not so great as he at first supposed.

Locating Leakage

There are numerous appliances available for locating leakage, such as the aquaphone, Darley leak locater, detectophone, geophone, sonofone, sonograph and sonoscope. All these work on the principle of the audibility of water flowing through a leak. The Clark leak indicator operates through loss of pressure and is used for services. Water pressure diagrams also are useful in locating leakage. Pipes may be located by the detector, wireless pipe locator and similar devices.

Locating Leaks with an Aquaphone

The following useful suggestions on locating leaks with the aquaphone was given by E. O. Sweet, Chief Engineer, Birmingham Water Works Co., Birmingham, Ala., in *Municipal News and Water Works.*

If you send a man out to locate leaks with an aquaphone, make him take along a hydrant wrench and a curb stop key. Insist that if he hears a leak on a service that he close the curb stop and listen again. If he does not hear it then, the leak is beyond the meter, and he should stop long enough to ascertain if the meter is catching the leak. If he hears a leak on several services in the block, make him stop long enough to find on which service it sounds loudest. This is the point nearest the leak and it will save time for the repair men to have this knowledge. Another inexpensive and quick way of finding leaks in our larger cities is to send men through the large trunk storm sewers. Many leaks have we found by so doing. Another quick method is to look into all telephone company duct manholes. Water will often be found entering their ducts and flowing to a manhole.

Locating Pipes and Leaks with Electric Pipe Locator

Carl A. Hechmer, Department Engineer, Washington Suburban Sanitary District, Hyattsville, Md., gives the following in *Water Works:*

Locating Pipes.—There are several instruments on the market which aid maintenance work on distribution systems. The electric pipe locator is one of them and if used carefully is a very valuable instrument. We have found it capable of doing all the things claimed for it by the manufacturers and we have saved its cost many times in locating old pipes. We recently took over the control of a small water system containing several miles of pipe lines and about 50 service connections. No drawings or records were available and we used the pipe locator to map the system. Pits dug on the main lines to install control valves and on all service pipes to install meter housings revealed, without exception, that the locator had indicated the correct location. After a little practice with the locator anyone can use it and depend on the results.

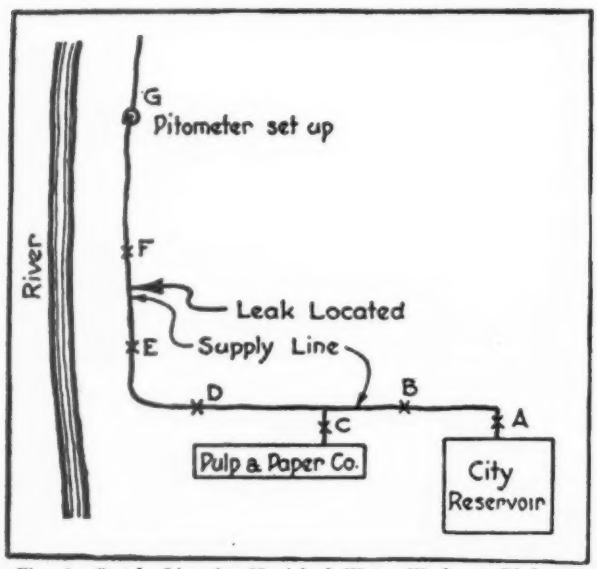


Fig. 1.—Supply Line for Municipal Water Works at Piedmont

Locating Leaks.—We have also saved hundreds of dollars using the electric leak locator in finding leaks on pipe lines, especially under improved streets. The first time we used the instrument we located a bad leak under a concrete street, the instrument having indicated the leak within 18 in. of the broken pipe, although water was coming out from both sides of the pavement for a distance of 25 ft. and the largest volume of water was coming out at about 20 ft. from the point at which the pipe was actually leaking.

The aquaphone is another instrument which we have found very useful. It sells for only a few dollars and resembles a telephone receiver. It is used to test house plumbing for leaks and to detect valves on distribution systems which fail to shut off the water tightly.

A dip neddle is almost an indispensable instrument for locating valve and curb cock boxes which have become covered with earth or paving material. It depends on the principle of magnetism, the iron box attracting the magnetized needle, causing it to dip when it is passed over the box.

Locating Leaks with Pitometer and Geophone

A combination of the pitometer and geophone in the hands of an experienced man can produce excellent results in locating leaks. In April, 1924, *Water Works,* Messrs. J. N. Chester and E. E. Bankson described how this combination was used at Piedmont, Va., and Patton, Pa.

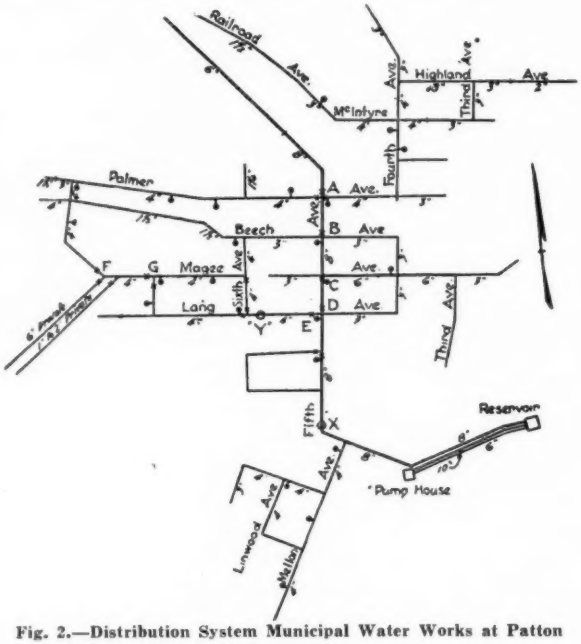


Fig. 2.—Distribution System Municipal Water Works at Patton

Principle of Simple Case.—The experience at Piedmont may be used to illustrate the principle of the most simple case, which may be described by use of Fig. 1, where the supply line is shown coming from the gravity source of the city reservoir, with very few services on the supply line previous to its entrance to the reservoir; the service of the pulp and paper company being the only one here shown.

For some years the paper company has been looked upon as the culprit who was stealing water from the city's supply lines. The suggestion that "the pitometer would produce the evidence brought forth the response that they were positive there were no leaks in the line because they had carefully watched that feature and, from experience, they had found that the leaks always readily came to the surface, anyway. The approximate location of valves are shown at A, B, C, D, E and F, and the pitometer set-up shown at

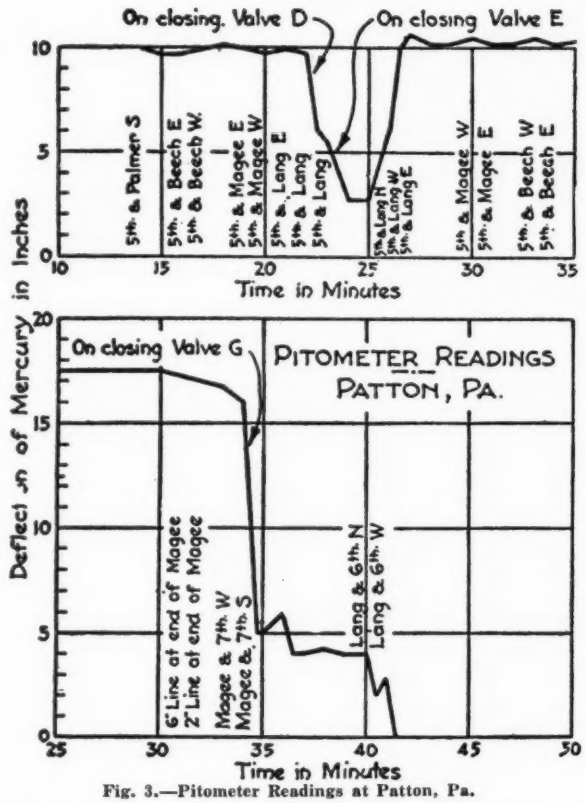


Fig. 3.—Pitometer Readings at Patton, Pa.

G, where it was determined that practically the full supply was passing.

After the pitometer was in place and ready for operation, the valves were closed in succession from A to F at time of low flow in the night. No reduction in the flow passing the pitometer at G was noted until after valve F had been closed, which means that the leakage was between E and F, and by the process of a few setups, with the pitometer run from F towards E, together with the use of a geophone, we finally located the leak which was creating all the trouble and which was running into the river below the ordinary flow line in such a way that it had never been detected all these years.

How Leakage Is Determined for a Distribution System.—The experience at Patton may be used to demonstrate the more complicated case, and this would apply to any size of system by the process of breaking that system up into parts. The distribution system for Patton is shown on Fig. 2.

Valves had been closed in certain parts of the system in such a way that valves A, B, C, D, E, F and G would serve as controlling points and with the pitometer at X, valves A, B, C and D were closed at the time of low flow in the night and no reduction of flow passing the pitometer was indicated until the valve D was closed, which meant that the leak was between C and D and was later definitely located by means of a geophone and again when valve E was closed a second reduction was noted. The pitometer was then set up at Y and the three valves at F were closed with no reduction in flow, but on closing G a decided decrease was observed, indicating that the leak was between F and G, which was also located by the geophone, in each case the leak flowing away underground unobserved. Pitometer readings for the case are shown on Fig. 3.

The process as described for Patton required only a few minutes for each operation of closing a series of valves and then opening them in the reverse order as a means of using the increases in flow as a check on the original decreases in flow during the operation of closing the valves.

Several examples like this could be cited where only two or three nights have been consumed in finding the serious leaks and the superintendents of some of these plants now swear by the geophone and refuse to be without one, such as at Etna, Edgeworth and West Newton, Pa. The survey at Etna, Pa., of about three nights' work, discovered two or three major leaks which reduced the electric pumping bill from about $500 or $350 per month.

Cleaning Cast Iron Water Mains

An interesting account of the experiences and results obtained in cleaning cast iron pipe lines was given by Charles Haydock, engineer, water companies, Philadelphia, Pa., in *Water Works*.

If the capacity of a long line appears to be decreasing or the pumping head increasing, the actual carrying capacity should be determined. If this is materially less than the theoretical capacity, a careful investigation should be made to determine the cause. A survey and determination of the hydraulic grade line is usually worth the cost, and will disclose any unusual conditions. If it is possible to shut down the line, static pressure or a siphon test will show how tight it is and a recording meter will complete the record. If there is no meter available, a pitot test can be made at a reasonable cost. The presence of consumers' taps and branch connections increases the difficulty of cleaning a line. After a pipe line has been cleaned, it is sometimes necessary to pump out the consumers' taps attached to same by means of a force pump for the reason that the particles dislodged in the interior of a pipe line may be forced into the corporation cocks. Branch connections and valves are sources of possible difficulty in cleaning a line by reason of the possibility of the cleaner sticking at such points. Having all this information available, it is usually possible to forecast the probable benefits of cleaning.

Cleaning Uncoated Pipe.—The writer's first experience in pipe cleaning was gained when two parallel lines from a reservoir to a railroad yard were cleaned. This line was particularly difficult, as it contains many bends and is of various sizes, the exact location of the reducers being then unknown. Some of this pipe was laid in the fifties and sections removed indicated that it was uncoated pipe, cast on the side in 9 ft. lengths. Before this line was cleaned, it carried a little more than half the theoretical capacity, while, after cleaning, this was increased to nearly 90 per cent. The other line from the same reservoir was 20 or 30 years old and is the usual 12 ft. coated pipe. Its capacity was increased from two-thirds to more than 90 per cent of that of new pipe. Such results are most encouraging. The unfortunate feature is that the results were not permanent and, about 5 years later, the capacity had decreased to approximately what it had been before cleaning. As the uncoated pipe had no protection at all, it is natural that it should have corroded rapidly following cleaning. This is an unusual condition, which, fortunately, is not often encountered.

Capacity Doubled by Cleaning.—The capacity of a pipe line approximately 3 miles long, half of which was 10 in., about 30 years old, the balance 12 in., 20 years old, was known to be inadequate and on investigation it was determined that this was due not only to tuberculation 1 in. thick in the 10 in. portion, causing a material reduction in area, but also to serious leakage in two creek crossings which did not show on the ground. In cleaning the 10 in. line, a joint missed at the first pouring was encountered. The lead in the pipe weighed about 50 lb. and measured 4 ft. along the bottom of the pipe. The cleaner picked this up and rolled a portion of it into a ball until the weight was so great as to stop the cleaner under the low water pressure available. As a result of this, it was necessary to cut the line to remove the cleaner. Due to the cleaning and reduction in leakage, the capacity was more than doubled, so that it was nearly equal to that of a new line. All of this increase in capacity can be credited to the job, as the leakage would not have been found unless cleaning had been done. A further result of this cleaning was that it was possible to discontinue the operation of a pumping station which was originally installed as an emergency or stand-by unit, but due to the decreased capacity of the line, it was necessary to operate the station continuously for some time.

Other Difficulties Located by Cleaning.—Another line cleaned was approximately 5 miles long. The available head was so low that there was not sufficient pressure to force the cleaner through the line. Rather than pull it through by means of a winch, a temporary boiler and pump were set up and water pumped into the line at a pressure sufficient to move the cleaner. In this way, the line was successfully cleaned and the capacity was greatly increased. As in the last case, this increase in capacity was sufficient to enable the discontinuance of a pumping station, which had originally been installed as an emergency unit, but had become practically a permanent installation by reason of the decreased capacity of the gravity line. The blow-off valves and automatic air vents on this pipe line had not been properly maintained, and were therefore not functioning. It was found that there was a considerable accumulation of sediment at the low points and that the capacity of the line was further reduced by air binding at the summits. Here again, while all of the increase in capacity was not due to the passage of the cleaner through the line, it is believed that all of the benefits are properly to be credited to the cleaning operation, for, if this had not been undertaken, the other difficulties would not have been located and it would have been necessary to continue the operation of the pumping station.

At another point, the discharge from a pumping station to a reservoir, consisting of parallel lines of 12 in. and 16 in. pipe, approximately 15 years old, was investigated, and it was decided to clean both lines, starting with the 12 in. After this was done, it was found that the 12 in. was carrying a much larger percentage of the flow and that the capacity had but increased approximately 30 per cent. These figures indicated that the cost of cleaning the 16 in. pipe line was unwarranted, as the reduction in pumping head which could have been accomplished by pumping through a clean line would not have decreased the fuel bill sufficiently to warrant the cost. The performance of this system is being observed and the 16 in. line will be cleaned as soon as capacity becomes a controlling feature or the possibilities of fuel saving become attractive. This line contained comparatively few tubercles, some of which were quite large, reaching a diameter of 1 in. and a height of ⅝ in. At one point in the line the cleaner was stopped by a small stone wedging between the cleaner and the seat ring. Upon removing the bonnet it was possible to pry the cleaner loose and the stone was removed. At another point a "missed" joint was encountered, the lead having spread out to a length of approximately 4 ft. and contained almost sufficient lead to run two joints. The water carried in this line is filtered. The total solids are always quite low and the alkalinity of the raw water seldom exceeds 12 to 15 parts per million, while in the spring it becomes very low. This water, while it is of a very desirable quality as to its total solid content, it is also very active and attacks the pipe line quite rapidly.

Another job consisted of cleaning 4 miles of 12-in. line, approximately 20 years old, the frictional loss through which before cleaning was nearly three times that of new pipe, and after cleaning, approximately the same as that of new line. The capacity was increased by approximately 35 per cent and the delivery pressure by 20 lb. under normal operating conditions. It would have been possible to obtain a greater increase in capacity by delivering at the same pressure, but the increase in pressure was a very desirable feature under the operating conditions. In cleaning this line, an axe complete with handle was recovered, also an iron wedge from a gate valve and a number of stones of various sizes, several of which were quite large.

Booster Station Discontinued as Result of Cleaning.—A 10½ mile section of 16-in. pipe line in the same system was also cleaned. As a result of this cleaning it was possible practically to discontinue the operation of a booster pumping station for the delivery without pumping after cleaning was greater than the delivery with pumping before cleaning. The gravity delivery of this line was increased 60 per cent. By reason of the increased flow, the percentage of increase when boosting after cleaning was only 30 per cent. The testing done in connection with this work disclosed the existence of two serious leaks along the pipe line, of which there was no indication on the surface of the ground. The tests also disclosed the existence of a valve of which there was no previous record. This valve was nearly closed, and under maximum delivery caused a material loss of head through the pipe line. The increase in capacity was therefore not due entirely to cleaning of the line, but was also due to the elimination of the leaks and the excessive loss of head.

The capacity of a 4 in. pipe line a mile long supplying a small railroad water station was found to be so reduced that

the laying of a new line was contemplated, but by cleaning a capital expenditure was avoided. The loss of head available in this line was so small that it was necessary to pull the cleaner through, at which time it was found that a summit was practically level with the intake, and the low points had material quantities of sediment. The cleaning was done in the winter time when the ground was covered with a foot of snow. The location of this pipe line was not known definitely, and it was necessary to prospect for same. As a result of this, the cost of the work was at least double what it should have been. The increase of 40 per cent in capacity is sufficient to obviate the necessity of renewing the line for a considerable period in the future.

Cleaning 22 Miles of 16 Year Old Pipe.—During the past summer 22 miles of 12 in. trunk line have been cleaned. The cleaned line consisted of three sections, the longest of which is more than 13 miles. The increase in capacity due to cleaning this portion was approximately 35 per cent. The unit length cleaned was governed by the location of a number of 90° bends, through which it was not considered advisable to attempt to pass the cleaner. These units ranged in length from ½ to about 4 miles.

The second section of this line, more than 3 miles long, was cleaned with similar gratifying results. In this section the pressure was low, and considerable difficulty was experienced in cleaning on that account. Under certain conditions there was practically no flow previous to cleaning. After cleaning, under similar conditions, the flow was approximately 350,000 gal. per day. The percentage increase in such cases is hardly a fair criterion, but this improved condition is of the greatest value in the operation of the line.

Cleaning the third section of this line, which is more than 6 miles long, and carries ample pressure for cleaning, resulted in an increase in capacity of approximately 46 per cent. The cleaner successfully passed through no less than five 45° bends in this section, but did not pass through a sleeve which had been used to make a 15° bend. The ends of the pipe had not been properly brought together at this point and a large stone dropped into the space. The cleaner wedged against this and it was necessary to cut the line to remove it.

This pipe line is approximately 16 years old and carries a high quality of water which is quite active, and the tuberculation was sufficient to reduce the diameter of the line in many places. The tuberculation was not evenly distributed along the line as some sections were comparatively free, while others, as noted above, showed a reduced diameter. Cleaning this pipe line disclosed the usual number of foreign objects, including many stones, a 6 ft. piece of 2x4 in. lumber, a complete shovel and a shovel handle. No doubt the shovel itself will be recovered at some later date, probably under a valve or else by obstructing the cleaner. It seems impossible to keep such foreign objects out of a pipe line, and while it is most unfortunate that this is true, it is hardly likely that in the average case the capacity of a line is materially reduced unless they are collected at a critical point, such as a valve or bend.

These 22 miles of pipe line which were cleaned comprise the critical sections in a 48 mile length of 12 in. line. The benefits derived consist not only in the increased capacity, but an important item was in reducing outside purchases of water. There are comparatively few points along this line where water can be purchased. None of the available waters are equal in quality to the water carried by the line and they are also more corrosive and expensive.

Approximately 3 miles of 10 in. pipe line has been cleaned very recently. The water supply at this point is obtained from a large river which is always quite hard and frequently acid. In order to correct these conditions, the water is treated constantly without sufficient sedimentation capacity. As a result of this, the treated water is not properly settled and precipitation occurs in the pipe line. The water is relatively inactive and there were comparatively few tubercles, but the sediment from the treating plant had formed a coating approximately ¾ in. thick throughout the line. This coating was readily removed and was discharged from the blow-offs like molasses. The increase in capacity due to cleaning was 65 per cent, while, under operating conditions, 20 per cent more water is delivered at double the former pressure.

Summarizing the situation, it is apparent from the examples cited that in many cases, pipe cleaning, especially of long transmission mains, will produce very substantial benefits where there is a deficiency in capacity or pressure. All water companies do not have the problem of long transmission mains, but those which do, in many cases, would find it to their advantage to investigate same, as actual conditions may be determined only by observations.

Charge for Resuming Water Service

The practice of various cities in regard to making a charge for resuming water service after the payment of a delinquent bill is summarized as follows in *Water Works:*

Portland, Ore., Charges $1.—Until a few years ago a nominal charge of 50 ct. was made by the Bureau of Water Works of Portland, Ore., for turning on water after a delinquent bill was paid. After checking up the matter carefully we found that a charge of 50 ct. only barely covered the actual average cost to the bureau of the inspector's time in turning off and turning on the water. In many cases the bureau lost money on the inspector's time, not to say anything about cost of transportation, such as street car fare, use of bicycles, motorcycles or automobiles. It also found that people neglected to pay bills to such an extent, mainly on account of the small fee, that too much time was spent in turning water off and on instead of doing more important work. Therefore, the charge for such service was raised from 50 ct. to $1, the amount charged at the present time. In estimating such a charge one of course must take into consideration the area of a city. Portland, with a population of nearly 400,000, covers an area of 66 square miles, whereas Los Angeles, with a population of over a million people, covers an area of 355 square miles. We divide the city into three districts, namely the west side, east side and Albina or northeast district. Everything on the west side is handled from the city hall. East side and Albina districts are handled from separate city owned buildings with direct telephone wires to the city hall. A chief inspector and a crew of 32 inspectors do all the work of turning on and shutting off water, reading meters, inspecting for leaks, etc.—L. S. Kaiser, Superintendent Bureau of Water Works.

A 50 Ct. Charge at Indianapolis.—The Indianapolis Water Co.'s charge for turning on water after a delinquent bill is paid is usually 50 ct. Our rules approved by the Indiana Public Service Commission, permit us to charge $1 for this service. For years the charge has been limited to 50 ct. excepting in very unusual cases of chronic non-payment of bills. Of course it costs us more than 50 ct. considering the time of the man and truck to turn on the water, but 50 ct. seems to be the practice in this area—the other utilities, gas, electric light, etc., making this same charge.—H. S. Morse, Manager Indianapolis Water Co.

Charge at Cambridge, Mass.—The regulations of the Water Board at Cambridge, Mass., provide that a charge of $1 be made for turning on the water after it has been shut off for non-payment of bill.—T. W. Good, General Superintendent.

New Orleans Charges 50 Ct.—The regulations of the Sewerage and Water Board of New Orleans, La., provide for charge of 50 ct. for turning off and on of water and a 10 per cent addition to bills in case of delinquent bills. These charges, however, do not cover the cost of the items. There are an astonishing number of people whose cost for the collection of delinquent bills exceeded the delinquent fee charges by something like $6,000 last year. New Orleans water rates as now existing were made in 1913, and have been held as they now stand by legislative restriction, and 1926 conditions are somewhat different from 1913 conditions.—Geo. G. Earl, General Superintendent Sewerage and Water Board.

Practice at New Bedford, Mass.—The regulations of the water department provide that on bills remaining unpaid for 30 days a demand is issued for which a charge of 50 ct. is made. Fifteen days after this, if the bill still remains unpaid the water is shut off and not turned on again except on the payment of all prior charges plus $2. In view of the fact that it is necessary to visit the property once to shut off the water and again to turn on, also the extra office work involved, $2 does not seem to be too great a charge. Sixty days after date of bill the charge becomes a lien on the property and the expense of recording and discharging is added. The amount is usually $1.40.—S. H. Taylor, Superintendent.

$1 Charge at Jacksonville, Fla.—For many years past the city of Jacksonville, Fla., has charged $1 on account of turning off of service when the bill is unpaid. We also have a ruling that should the water be turned off and the customer turns it back on without authority, we take the meter out and make a charge of $3 in addition to paying the regular bill.—J. E. Pace, City Auditor.

Delinquency Charges at Somerville, Mass.—In cases of non-payment of water charges within the specified time the supply will be shut off and water will not again be let on until the charges along with $1 costs have been paid. Costs will be charged where the water has been ordered shut off for non-payment, though the bill be paid before the supply has been actually shut off.—Frank E. Merrill, Water Commissioner.

$1 for Turning Off and $1 for Turning On at Houston.—The city ordinance of Houston, Tex., containing the following regarding the "on and off" water charge: "In case the water has been turned off on account of waste or unauthorized use of same the water commissioner shall charge and collect the further sum of one dollar for turning off and one dollar for turning on."—Jas. H. B. House, Water Commissioner.

How Delinquent Bills Are Handled at Dallas.—The city ordinance provides a charge of $1 where the water is turned off for non-payment, and I believe that this is a just charge for this; however, the board of commissioners has seen fit to make this 75 ct. instead of $1, and this we collect in nearly all instances.—Jennings M. Moore, Secretary and Collector Dallas City Water Works.

$1 Charge at Tulsa, Okla.—The Water Department of Tulsa, Okla., makes a charge of $1 for turning on water after delinquent bill is paid. We feel that this a reasonable charge, inasmuch as the patrons would take advantage if we did not make a charge of this nature. The Water Ordinance of the city contains the following provisions regarding the payment of water bills:

"That all meters shall be read monthly and all service charges and water bills shall be due and payable monthly, at the office of the Commissioner of Water Works in the Municipal Building of the City of Tulsa, as hereinafter provided, to-wit:

"District No. 1 as above defined shall be mailed to such consumers not later than the 1st day of each month and such bills shall be paid not later than the 10th day of the month succeeding the end of the monthly period upon the basis of which the charge is made.

"District No. 2, as above defined shall be mailed to such consumers not later than the 8th day of each month, and such bills shall be paid not later than the 18th day of the month succeeding the end of the monthly period upon the basis of which the charge is made.

"District No. 3, as above defined shall be mailed to such consumers not later than the 17th day of each month, and such bills shall be paid not later than the 27th day of the month succeeding the end of the monthly period upon the basis of which the charge is made.

"In the event of the failure of any consumer to make payment of charges assessed against him on or before the date fixed herein such charge shall then become delinquent and a penalty of ten (10%) per cent of the amount due, shall be added thereto and service to such consumer may be discontinued without notice to him, in which latter event, charge of $1.00 will be assessed for shuting off and turning on water. The failure of any consumer to receive a statement of the amount of the charge due from him shall not constitute an excuse for the neglect, failure or refusal to pay the charge assessed against him when the same is due."—W. F. Anderson, Superintendent Water Department.

$2 Charge at Boston.—The Water Division of the Public Works Department of Boston, Mass., makes a charge of $2 for turning on water after a delinquent bill has been paid. This is added to the amount of the bill by the city collector, when payment is made. The receipted bill is then shown to the water income branch where an order is isued to the operating branch to turn on the water. The sum of $2 is a nominal charge, as under present working conditions, it does not cover the entire cost of the operation which includes—notification, shutting off, letting on, clerical work, etc., etc. In the olden days that amount of money practically covered the cost, but with increased wages and costs all along the line it now falls short. We consider the collection of the charge, not only as a partial reimbursement for the expense of collecting the bill, but also as a deterrent of delinquency. Whether it operates successfully in the latter capacity, I am not sure as my opinion is that delinquency is a chronic malady. We have the same old names regularly. It is a habit, and a bad one at that.—George H. Finneran, Superintendent.

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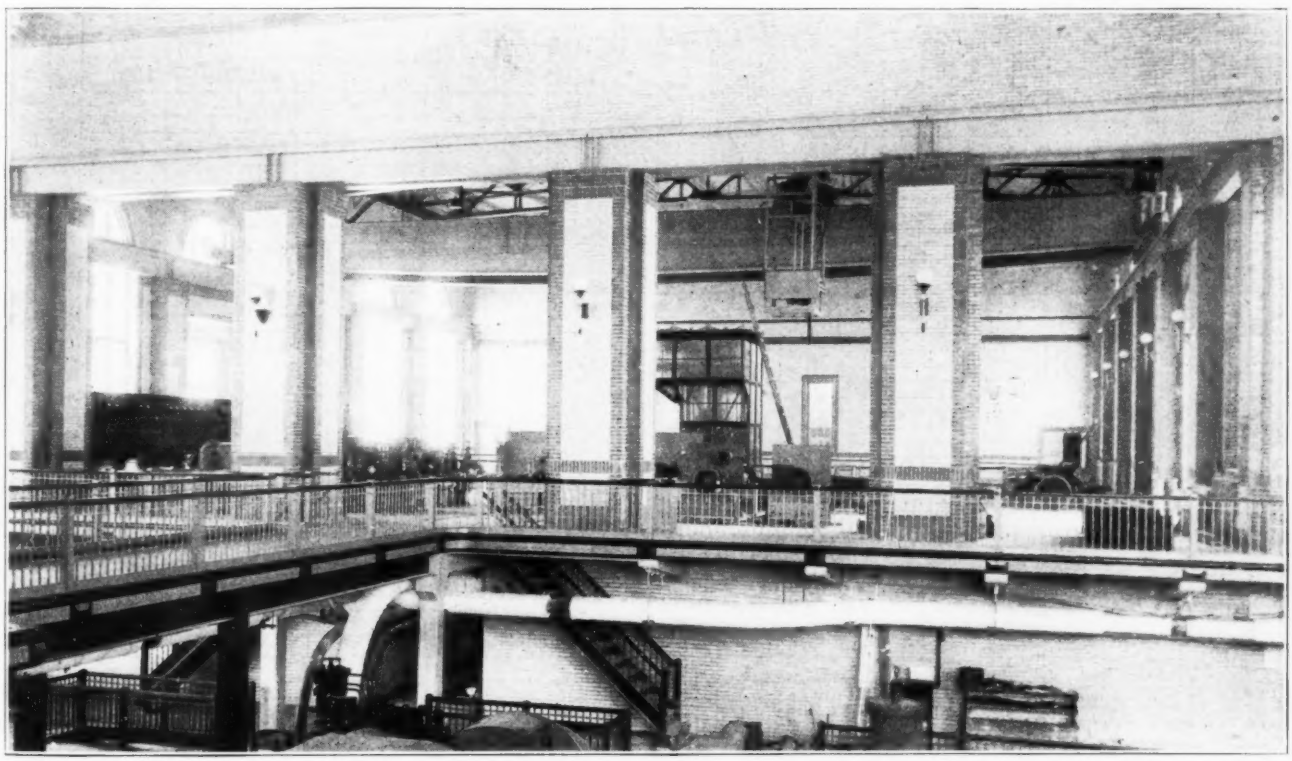

Engine Room, Howard Bend Plant, St. Louis City Water Works

Study & Farrar, Architects

Dunham Construction Co., General Contractors

Effect of Growth in Population on Water Consumption for Various Cities

From Water Works

		City	Period of Years		Per Cent of Services Metered		Population			Total Consumption (m g d.)			Per Capita Consump. (Gallons per Day)			Meter Rates				
			Years Taken	Length of Period	Beginning	End	Beginning	End	Annual Increase in % (Compounded Annually)	Beginning	End	Annual Increase in % (Compounded Annually)	Beginning	End	Annual Increase in % (Compounded Annually)	Minimum Charge		Domestic Rate per 1000 gals.	Intermediate Rate per 1000 gals.	Mfg. Rate per 1000 gals.
																Monthly	Annual			
Group No. 1 (Present Population over 1,000,000)	1	Detroit, Mich	1920-24	4	97	99	1,066,000	1,372,000	6.6	152.0	184.0	4.9	143	134	-1.5	$0.42	$5.00	$0.10	$0.08	$0.06
	2	Mass. Metropolitan Dist.	1913-24	11	58	95	1,110,000	1,300,000	1.4	103.8	124.1	1.7	94	95	0.1	0.67	8.00	0.21	0.19	0.18
	3	Cleveland, O	1908-24	16	94	98	519,000	1,074,000	4.7	52.1	151.2	6.9	100	141	2.2	0.50	6.00	0.08	0.08	0.08
		Straight average for Group No. 1		10	83	97	898,000	1,249,000	4.2	102.6	153.1	4.5	112	123	0.3	0.53	6.33	0.13	0.12	0.11
Group No. 2 (Present Population between 250,000 and 1,000,000)	4	Boston, Mass	1913-24	11	41	94	733,000	788,000	0.6	79.4	87.7	0.9	108	111	0.3	0.67	8.00	0.21	0.19	0.18
	5	San Francisco, Ca.	1919-24	5	100	100	565,000	610,000	1.6	35.7	59.3	1.9	63	64	0.4	0.78	9.36	0.40	0.33	0.30
	6	Milwaukee, Wis.	1901-24	23	89	99	300,000	550,000	2.7	24.0	69.0	4.7	80	125	2.0	0.17	2.00	0.10	0.09	0.09
	7	Newark, N.J	1917-24	7	88	96	418,000	446,000	1.0	45.6	45.6	-0.6	109	98	-1.5	0.50	6.00	0.15	0.14	0.13
	8	Cincinnati, O	1914-24	10	61	100	397,000	425,000	0.7	50.8	48.9	-0.4	128	115	-1.1	0.40	4.80	0.16	0.16	0.16
	9	Minneapolis, Minn	1908-24	16	76	100	277,000	417,000	2.6	17.8	42.8	5.6	64	102	2.9	0.33	4.00	0.08	0.08	0.08
	10	New Orleans, La	1918-24	6	100	100	389,000	412,000	1.0	35.2	45.4	5.4	85	110	4.3	0.25	3.00	0.11	0.09	0.07
	11	Kansas City, Mo	1916-24	8	70	83	315,000	384,000	2.5	32.7	48.3	5.0	104	126	2.4	0.70	8.40	0.22	0.17	0.11
	12	Rochester, N.Y	1908-24	16	87	99	202,000	309,000	2.7	17.6	26.4	2.6	87	86	-0.1	0.50	6.00	0.18	0.17	0.15
	13	Providence, R.I.	1902-24	22	84	95	198,000	284,000	1.6	11.6	23.6	3.3	58	83	1.6	0.67	8.00	0.24	0.17	0.11
	14	Toledo, O.	1910-24	14	85	100	168,000	282,000	3.8	15.6	29	4.5	93	102	0.7	0.71	8.50	0.13	0.12	0.11
	15	St. Paul, Minn	1914-24	10	85	99	225,000	280,000	2.2	13.5	20.4	4.2	60	73	2.0	0.30	3.60	0.09	0.09	0.09
	16	Columbus, O	1910-24	14	91	99	182,000	270,000	2.8	13.8	23.2	3.8	76	86	0.9	0.40	4.80	0.16	0.16	0.15
		Straight average for Group No. 2		12	81	97	336,000	420,000	2.0	30.1	42.1	3.1	86	99	1.1	0.49	5.88	0.17	0.15	0.13
Group No. 3 (Present Population between 100,000 and 250,000)	17	San Antonio, Tex.	1913-24	11	27	60	120,000	210,000	5.2	12.6	23.0	5.7	105	109	0.4	0.80	9.60			
	18	Worcester, Mass	1896-1924	28	93	98	103,000	192,000	2.2	6.1	16.3	3.6	60	84	1.3	0.33	4.00	0.20	0.15	0.10
	19	Hartford, Conn.	1905-24	19	99	100	91,000	182,000	3.7	6.2	16.2	5.2	69	89	1.3	-	-	0.16	0.16	0.10
	20	Dayton, O	1917-24	7	81	87	141,000	170,000	2.8	12.7	16.7	3.9	90	98	1.2	0.55	6.60	0.13	0.09	0.07
	21	Grand Rapids, Mich	1915-24	9	76	100	125,000	180,000	2.8	10.5	15.9	4.8	84	99	1.9	0.67	8.00	0.09	0.09	0.09
	22	Springfield, Mass.	1913-24	11	94	99	99,000	151,000	3.9	10.7	13.5	2.1	108	89	-1.8	0.67	8.00	0.18	0.08	0.07
	23	New Bedford, Mass.	1914-24	10	96	93	108,000	145,000	3.0	7.4	9.7	2.7	69	67	-0.3	0.42	5.00	0.16	0.10	0.10
	24	Fall River, Mass	1900-24	24	94	100	108,000	131,000	0.9	3.8	6.8	2.5	35	52	1.7	-	-	0.28	0.20	0.14
	25	Lowell, Mass.	1909-24	15	77	90	105,000	125,000	1.2	5.2	6.5	1.5	50	52	0.3	-	-	0.28	0.28	0.28
	26	Yonkers, N.Y.	1909-24	15	100	100	76,000	110,000	2.5	7.6	13.4	3.8	100	122	1.3	0.87	8.00	0.21	0.13	0.13
	27	Lawrence, Mass.	1905-24	19	88	97	69,000	103,000	2.1	3.0	4.6	2.3	43	45	0.3	0.58	7.00	0.20	0.20	0.20
	28	Somerville, Mass	1913-24	11	61	94	83,000	101,000	1.8	6.0	7.8	2.4	72	77	0.6	0.50	6.00	0.16	0.16	0.12
		Straight average for Group No. 3		15	82	93	102,000	148,000	2.7	7.6	12.5	3.4	74	82	0.7	0.58	6.91	0.19	0.15	0.13
Group No. 4 (Present Population between 25,000 and 100,000)	29	Brockton, Mass.	1911-24	13	100	100	69,000	84,000	1.5	2.7	4.2	3.5	39	50	1.9	-	-	0.26	0.18	0.14
	30	Manchester, N.H.	1904-24	20	70	85	62,000	83,000	1.5	3.1	6.4	3.7	50	77	2.2	0.67	8.00	0.13	0.13	0.10
	31	Malden, Mass.	1913-24	11	99	99	48,000	53,000	0.9	2.23	2.86	2.3	46	54	1.4	0.58	7.00	0.21	0.20	0.19
	32	Quincy, Mass.	1919-24	11	86	91	36,000	53,000	3.6	2.7	4.4	4.5	76	82	0.7	1.17	14.00	0.31	0.24	0.19
	33	Woonsocket, R.I.	1893-1923	30	86	96	23,000	51,000	2.7	0.6	3.1	5.6	24	60	3.1	0.83	10.00	0.28	0.14	0.10
	34	Madison, Wis.	1897-1924	27	89	100	18,000	48,000	3.7	0.8	4.8	6.9	44	102	3.2	-	-	0.12	0.09	0.06
	35	Chelsea, Mass.	1913-24	11	98	100	36,000	47,000	2.5	2.88	3.55	1.9	80	76	-0.5	0.50	6.00	0.15	0.15	0.15
	36	Medford, Mass	1913-24	11	100	100	26,000	46,000	5.3	1.2	2.4	6.5	48	53	0.9	0.50	6.00	0.20	0.16	0.16
	37	Everett, Mass.	1913-24	11	40	89	37,000	44,000	1.6	2.4	4.5	5.9	65	102	4.2	0.50	6.00	0.16	0.15	0.12
	38	Taunton, Mass	1905-23	18	46	88	28,000	37,000	1.6	1.9	3.6	3.6	69	99	2.0	0.75	9.00	0.25	0.18	0.11
	39	Waltham, Mass.	1919-24	5	91	100	31,000	33,000	1.2	1.9	2.2	3.0	61	66	1.6	0.83	10.00	0.22	0.15	0.15
	40	Revere, Mass.	1913-24	11	50	87	21,000	31,000	3.6	1.39	2.29	4.7	67	74	0.9	0.83	10.00	0.19	0.15	0.15
	41	Watertown, Mass	1913-24	11	100	100	14,000	26,000	5.8	0.87	1.66	6.1	62	63	0.2	0.83	10.00	0.33	0.30	0.22
		Straight average for Group No. 4		15	81	95	35,000	49,000	2.7	1.9	3.5	4.5	56	74	1.7	0.73	8.73	0.22	0.17	0.14
Group No. 5 (Present Population below 25,000)	42	Arlington, Mass.	1913-24	11	100	100	13,000	24,000	5.8	0.79	1.40	5.3	63	59	-0.5	1.25	15.00	0.20	0.16	0.16
	43	Melrose, "	1913-24	11	100	100	17,000	19,000	1.0	1.16	1.25	0.9	68	64	-0.5	0.75	9.00	0.22	0.20	0.20
	44	Winthrop, "	1913-24	11	100	100	11,000	18,000	4.6	0.69	0.97	3.2	60	55	-0.7	1.00	12.00	0.24	0.24	0.24
	45	Milford, "	1910-24	14	57	89	15,000	18,000	0.5	0.8	0.9	0.9	51	56	0.7	1.00	12.00	0.53	0.25	0.21
	46	Belmont, "	1913-24	11	100	100	6,300	14,000	7.5	0.46	0.89	6.2	73	64	-1.2	0.83	10.00	0.24	0.20	0.20
	47	Milton, "	1913-24	11	100	100	8,500	11,000	2.3	0.35	0.54	4.6	39	47	1.7	1.00	12.00	0.33	0.33	0.33
	48	Swampscott, "	1913-24	11	100	100	6,600	8,400	2.2	0.42	0.73	5.2	63	87	3.0	0.92	11.00	0.40	0.40	0.40
	49	Stoneham, "	1913-24	11	87	100	7,800	8,200	0.5	0.41	0.60	3.5	53	73	3.0	0.83	10.00	0.45	0.32	0.26
	50	Lexington, "	1913-24	11	79	100	5,400	7,000	2.4	0.36	0.45	2.1	67	64	-0.4	1.00	12.00	0.30	0.22	0.20
	51	Nahant, "	1913-24	11	60	94	1,400	1,600	1.2	0.17	0.20	1.5	125	126	0.2	0.83	10.00	0.25	0.25	0.25
		Straight average for Group No. 5		11	88	98	9,200	13,000	2.8	0.56	0.79	3.3	66	70	0.5	0.94	11.30	0.31	0.26	0.24
Group No. 6 Mass. Metropolitan Water District	4	Boston, Mass.	1913-24	11	41	94	733,000	788,000	0.6	79.4	87.7	0.9	108	111	0.3	0.67	8.00	0.21	0.19	0.18
	28	Somerville, "	1913-24	11	61	94	83,000	101,000	1.8	6.0	7.8	2.4	72	77	0.6	0.50	6.00	0.16	0.16	0.12
	31	Malden, "	1913-24	11	99	99	48,000	53,000	0.9	2.23	2.86	2.3	46	54	1.4	0.58	7.00	0.21	0.20	0.19
	32	Quincy, "	1913-24	11	86	91	36,000	53,000	3.6	2.7	4.4	4.5	76	82	0.7	1.17	14.00	0.31	0.24	0.19
	35	Chelsea, "	1913-24	11	98	100	36,000	47,000	2.5	2.88	3.55	1.9	80	76	-0.5	0.50	6.00	0.15	0.15	0.15
	36	Medford, "	1913-24	11	100	100	26,000	46,000	5.3	1.2	2.4	6.5	48	53	0.9	0.50	6.00	0.20	0.16	0.16
	37	Everett, "	1913-24	11	40	89	37,000	44,000	1.6	2.4	4.5	5.9	65	102	4.2	0.50	6.00	0.16	0.15	0.12
	40	Revere, "	1913-24	11	50	87	21,000	31,000	3.6	1.39	2.29	4.7	67	74	0.9	0.83	10.00	0.19	0.15	0.15
	41	Watertown, "	1913-24	11	100	100	14,000	26,000	5.8	0.87	1.66	6.1	62	63	0.2	0.83	10.00	0.33	0.30	0.22
	42	Arlington, "	1913-24	11	100	100	13,000	24,000	5.8	0.79	1.40	5.3	63	59	-0.5	1.25	15.00	0.20	0.16	0.16
	43	Melrose, "	1913-24	11	100	100	17,000	19,000	1.0	1.16	1.25	0.9	68	64	-0.5	0.75	9.00	0.22	0.20	0.20
	44	Winthrop, "	1913-24	11	100	100	11,000	18,000	4.6	0.69	0.97	3.2	60	55	-0.7	1.00	12.00	0.24	0.24	0.24
	46	Belmont, "	1913-24	11	100	100	6,300	14,000	7.5	0.46	0.89	6.2	73	64	-1.2	0.83	10.00	0.24	0.20	0.20
	47	Milton, "	1913-24	11	100	100	8,500	11,000	2.3	0.35	0.54	4.6	39	47	1.7	1.00	12.00	0.33	0.33	0.33
	48	Swampscott, "	1913-24	11	100	100	6,600	8,400	2.2	0.42	0.73	5.2	63	87	3.0	0.92	11.00	0.40	0.40	0.40
	49	Stoneham, "	1913-24	11	87	100	7,800	8,200	0.5	0.41	0.60	3.5	53	73	3.0	0.83	10.00	0.45	0.32	0.26
	50	Lexington, "	1913-24	11	79	100	5,400	7,000	2.4	0.36	0.45	2.1	67	64	-0.4	1.00	12.00	0.30	0.22	0.20
	51	Nahant, "	1913-24	11	60	94	1,400	1,600	1.2	0.17	0.20	1.5	125	126	0.2	0.83	10.00	0.25	0.25	0.26
		Straight average for Group No. 6		11	83	97	62,000	72,000	3.0	5.8	6.9	3.8	69	74	0.7	0.81	9.67	0.25	0.22	0.21
		Mass. Metropolitan Dist	1913-24	11	58	95	1,110,000	1,300,000	1.4	103.8	124.1	1.7	94	95	0.1			0.21	0.19	0.18
Group No. 7 (Cities with small % of metering)	52	New York City, N.Y.	1920-24	4	27	25	5,664,000	6,015,000	1.5	734.9	789.2	1.7	130	131	0.2	-	-	0.13	0.13	0.13
	53	St. Louis, Mo.	1912-24	12	7	8	711,000	811,000	1.1	83.5	113.1	2.6	120	140	1.3	0.17	2.00	0.17	0.10	0.07
	54	Indianapolis, Ind.	1910-24	14	11	23	237,000	362,000	3.1	19.3	32.8	3.8	81	90	0.8	1.40	16.90	0.19	0.16	0.09
		Straight average for Group No. 7		10	15	19	2,204,000	2,396,000	1.9	279.2	311.6	2.7	110	120	0.8	0.78	9.40	0.16	0.13	0.10

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HAUCK MANUFACTURING COMPANY

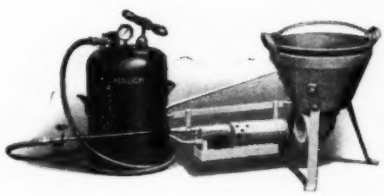
Established 1900

141 Tenth Street, Brooklyn, N. Y.

Oil Burners and Oil Burning Equipments

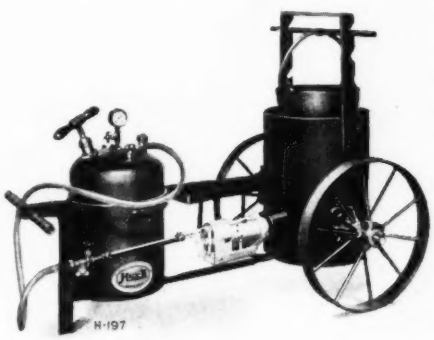
Products: KEROSENE LEAD AND COMPOUND MELTING FURNACES AND TORCHES FOR MELTING LEAD OUT OF PIPE JOINTS; STEAM THAWERS; WEED BURNERS.

Also Asphalt Surface and Tool Heaters; Asphalt Pitch and Tar Melting Kettles; Circular and Straight Flame Kerosene Burners for heating kettles; Concrete Heaters; Thawers; Oil Burning Salamanders and Water Heaters; Kerosene Torches of all sizes.



The Hauck Combination Lead Melting Furnace and Torch—on legs—burns kerosene and is made in two sizes—200 lbs. (as illustrated) and 450 lbs. capacity. Melts 200 lbs. of lead in 10 minutes; 450 lbs. in 20 minutes. The torch equipment is instantly detachable for melting lead out of pipe joints and general heating and repair work. Both furnaces are equipped with the new "slide-rail" HEAT CONTROL—an exclusive Hauck feature. For full heat, simply push burner forward on "slide-rail"; for less heat, pull burner away from furnace. Send for bulletin No. 101.

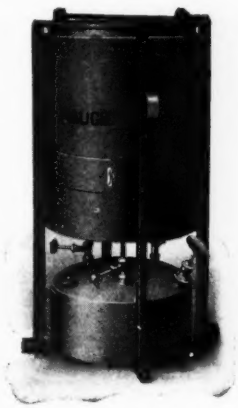
The Hauck Combination Lead Melting Furnace and Torch on Roller-Bearing Wheels—burns kerosene and is made in three sizes, 200 lbs. 450 lbs. (as illustrated) and 850 lbs. capacity. Melting time for small sizes as above; 850 lbs. in 35 minutes. These furnaces are also equipped with the new "slide-rail" HEAT CONTROL—an exclusive Hauck feature, as described above. Ask for bulletin No. 101.



The Hauck Asphalt Tar and Pitch Kettles made in two sizes—50 and 100-gallon capacity, on steel and rubber-tired wheels. Ask for special bulletin.

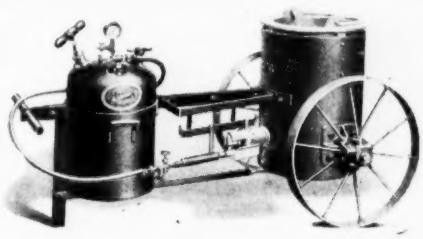
The Hauck Steam Thawing Outfit illustrated is very popular with Water and Fire Departments for thawing out frozen water hydrants and pipe lines (burns gasoline or kerosene as specified). Raises steam in four minutes. Operates 40 minutes steadily. Steam generator capacity 3 gallons. Furnace tank capacity 1½ gallons. Also made in 10-gallon steam generator size, on wheels. Send for special Steamer bulletin.

The Hauck Weed Burners burn kerosene. Made in a number of sizes for hand, "one-man" and "two-men" use. Burn weeds just as they stand, green, on the stalk. Destroy the seeds. Get into all kinds of places. Great labor-savers. Send for bulletin No. 1013.



The Hauck Compound Melting Furnace on Legs for Leadite, Hydrotite, G-K Sewer Joint and other compounds (burns gasoline). Three burners are used for melting initial batch; thereafter only one or two burners are used. Average fuel consumption per 8-hr. day, 2¾ gallons. Cast iron pot holds approximately 120 lbs. compound; 8 gallons liquid. Send for bulletin No. 102.

The Hauck Compound Melting Furnace on roller-bearing wheels for Leadite, Hydrotite, G-K Sewer Joint and other compounds (burns gasoline or kerosene as specified). Cast iron pot holds approximately 120 lbs. compound; 8 gallons liquid. Equipped with the new "slide-rail" HEAT CONTROL — an an exclusive Hauck feature, as described under Lead Melting Furnaces. Ask for bulletin No. 102.



Kinks for the Water Works Superintendent

Many practical and time saving kinks in the water works field, often original ideas of the operating man, remain untold because to the inventor they either seem too simple or he does not have the time or inclination to write them up. However, many water works operators have realized the value of exchanging experiences and in the following pages we are reprinting from *Municipal News and Water Works* a number of kinks brought out at these discussions.

Paper Wad Method of Cleaning Service Pipe.—In Worcester, Mass., we use cement lined pipe for houses and other purposes up to 1¼-in. pipe, all the pipe lined by our own men. The pipe itself practically never shows any corrosion. Corrosion shows at tees, inside wall and at gooseneck and corporation at main. On relieving of pressure we run ⅛-in. gas pipe rods out to the gooseneck, cleaning the service thoroughly, should there be corrosion at any couplings. If we do not get satisfactory pressure then, we then take a small wad of toilet paper, inserting it into the service pipe, and then attach a Blake & Knowles force pump, forcing the wad of paper through the service until we have pressure on the pump of at least five or more pounds more than the pressure on the main at that point. When we have the pressure on the pump at the point that we want to force the wad through the corporation stop, a man will open the stop at the main and with the wad of paper and the pressure up to the stop at main it requires very little pumping to force the wad through the corporation cock, where it will dissolve in the main. After that is done, owners have an ample supply at meters for a number of years again. We have been cleaning service pipes for a number of years in this way with perfect results.—Joseph A. Hoy, Worcester, Mass.

Ridding a Reservoir of Tadpoles.—In the city of Wilmington, N. C., we have just an open reservoir. Last summer I noticed an accumulation of tadpoles and how to get rid of them was a question. I was talking to an old fisherman who hangs out at our place occasionally and he told me to get some trout and put them in the reservoir. I got the trout and put them in and in less than one week's time you would never know there was a tadpole in the reservoir. We never have any algae growth in our basins at all because we draw out every day about 5 or 6 ft. and at night when the peak load is off, we fill it up again. We still keep those fish and they look every day for nourishment. If anyone is bothered with tadpoles or algae growth, I would suggest they use trout, as these trout will clean the place right up. They are good housekeepers.—J. H. Sweeney, Wilmington, N. C.

Value of Laboratory Data at Filter Plant.—It is valuable to have data at each plant, showing the character of the water put out at any particular time. Suppose a typhoid epidemic should occur at Salisbury. If you had no data regarding the bacteriological quality of the Salisbury water for the month preceding the outbreak, except for the monthly sample submitted to the State Laboratory, Mr. Craig would have no data to submit before a jury to prove that the water was not capable of producing disease at that time, and those who had cases of typhoid in their family might be able to recover damages. On the other hand, if he had data to support his claims for the purity of the water for weeks prior to the typhoid outbreak he would have evidence to show that the water was not capable of producing disease at the time. Plant data, showing the physical, chemical and bacterial characteristics of the water, is valuable to the superintendent of the plant and to the city, as is the collection of morbidity and morality and birth rates by the State Bureau of Vital Statistics. So you should have a certain amount of analytical work done at each plant laboratory.—J. W. Kellogg, Raleigh, N. C.

Location of Water Services.—We have had a rule for some time to put no services in except from the front of the house. We give the owner the privilege of locating the service anywhere in the front of his lot that he desires. We determine the front of his lot by the street and number by which the post office department delivers his mail. If a man happens to be on a corner and wants a service from the side, and he gets his mail according to the number on the front of the house, that is the way he has to take the service. That causes a little bit of discussion sometimes, but as a rule the man finally realizes that it is reasonable.

We put curb wells on all our services and also meters, and they are located so that we have very little trouble if anything happens. For some of the older services we have to use an electric pipe locater. We have used that to very good advantage for some of the old services where records have been lost. It works very well after you get acquainted with it.—J. E. Gibson, Charleston, S. C.

Mud Balls in Filter Beds.—I have noticed in washing out the filters that the gravel seemed to be cemented. I went down into one filter and took out the gravel and after I replaced it, I had the same trouble. The mud balls don't form all the way around but probably in two or three places a foot or more in diameter. I never let them run very long without breaking them up.

Before I started using a rod to break them up they would run probably three months without any disturbance. I have had these mud balls show up nearly the height of the trough. The water is very clear as a usual thing and I can see the bed when the filter is full, but at this time the water is a little cloudy.

I drain the water down and prepare the filter to be washed; I drain it down within 3 or 4 in.—say 4 in.—and start the wash water from there. That gives any operator, even at night, a chance to see the mud balls so he can get a rod and break them up. I also believe that has a tendency to eliminate them.

I have talked to people who have the same type of drain and they have not had the trouble that I have had. It may be in the installation more so than it is in the design.—R. G. Shell, Fayetteville, N. C.

Valve Operation and Maintenance.—Valves must be operated regularly to keep them in proper working condition. The Fire Underwriters require annual inspection, but in rural sections with a large percentage of unpaved streets, more frequent inspections are necessary if the valve boxes are to be kept to proper grade, ready for emergency operation. Frequently, when a shut down is attempted, one or two valves will be found leaking through, although the stems have been turned down tightly. Generally such valves can be made tight by operating them up and down, bringing the gate down into the groove hard each time and then opening the valve about one quarter way. The trouble is usually caused by the accumulation of sediment under the seat. Each time the gate is pushed down into the groove a small portion of this sediment is pushed out the sides. The high velocity of the water through the partly opened valve removes what is pushed out and the operation is repeated until the groove is sufficiently cleaned to allow the gate to seat properly, thereby cutting off the flow of water. Of course, if the groove is filled with large stone or jointing material, the valve must be dug up and taken apart for repairs. I remember operating one 16-in. valve thirty times and getting a perfectly tight shut down. The valve had not been operated for a long time, having been declared worn out since it always allowed a large volume of water to pass with the gate turned down hard with levers on the key.

With constantly changing street grades, valve boxes must be lowered and raised frequently. We use the sliding type of adjustable valve box and formerly experienced trouble in keeping the boxes to grade after changes in unimproved streets carrying heavy traffic had been made. By using two pieces of plank 12 in. long and 6 in. wide, cut to fit around the barrel of the lower section of the box in the shape of a clamp, more bearing surface is given the upper section and we now have little trouble with boxes being pushed down below grade.—Carl A. Heckmer, Salisbury, Md.

Making Out Water Bills.—We have changed our system of making out bills and it has worked so successfully that I think something ought to be said about it. We have a little over 6,300 bills to make out—water and light—and it used to take one girl practically all of her time to make these out. We have installed a Burroughs billing machine with an addressograph so that the girl is now able to issue the bills in about ten days and does not have to work very hard to do that. This machine makes three copies of the

bill—the customer's bill, the receipt stub, and our own stub and at the same time makes a copy of the bill and enters it up on a loose leaf ledger sheet which holds two years' records. It also totals up the amount of meter readings, both water and light separate, and the totals of the individual bills. We think that helps us because by comparing the meter readings at our pumping station with the total amount of water accounted for, we can get at our leakage a whole lot easier.—P. J. Dishner, High Point, N. C.

Stopping Flow from Broken Corporation Cocks.—In cases of this kind I use a long steel tool squared and tapered at each end; one end to enter the inlet end of a ¾ in. corporation cock and the other to enter the end of a 1 in. corporation cock. I insert the proper end of the tool into the brass ferrule ieft in the main and drive it home rather snugly. A pipe wrench will enable you to back the ferrule out of the main. Now take a closed corporation cock, insert the outlet end in the coupling of the proper size galvanized pipe and you can screw the cock into the main against the pressure. In case the main is so shallow that the force of the water coming out of the main will jet all of the water out of the hole you can use two heavy boards laid down across the hole. Cut a V-notch in each board, bring these notches together just over the hole in the main and then work down through these notches to the main. It requires a little nerve and a good grip to get the cock centered in the hole, but it can be done. I have found this was much better than cutting off the main, especially where it was a large main or one that supplied a manufacturing district. Then it is easier and cheaper. After you have inserted the cock in the main you can dig down to the cock and remove the pipe and tighten the cock with a pipe wrench.—McKean Maffitt, Wilmington, N. C.

Remedying Air Bound Filters.—I had a rather interesting experience with air bound filters. The water pumping station is five miles from the filter plant. Originally we pumped direct from the mixing chambers. Of course we had a few leaks in the line but they were not serious enough to stop the mixer. One night there was a leak and a considerable amount of air got in the pipe line. We started pumping and increasing the pressure and this air dissolved in the water so that we had a large amount of dissolved air in the water and so soon as the head got up to about 4 or 5 ft., the filter controller would then go under a negative head. Then, when the plant was shut down the filter would bubble quite vigorously and break holes larger than your fist in the surface of the filter. That would increase the bacterial count in the filter effluent.

I tried several methods to get rid of that. I thought at first that the air was in the manifold. But that did not have any effect. Since that time we have put in a raw water reservoir above the filter plant and I placed the inlets to that reservoir high up on the wall. The wall slopes and the water would flow down this wall and be about the same as an aerator on the raw water and since we put that in we have not had any air bound filters.—F. V. Fields, Mooresville, N. C.

Solving a Sewer Problem.—If any of you have charge of a sewer system this might be of interest to you. We had a sewer line to run to a section that had about twenty houses in it. To get to this section the line came to the surface of the ground. It was simply a case of leaving out this section or putting in an invert. So I tried the invert. I ran the line at the regular grade until it was within 6 in. of the surface. Then built a manhole. The inlet lines to the manhole were put 24 in below the outlet inlet lines to the manhole were put 24 in. below the outlet before it would run out. The laterals on the low line were run out to the property line before any houses were connected up. At the ends of the two low lines there were installed flush tanks so that we could get a large flush of water once in a while. In the manhole at the break in the grade we installed a 1-in. water connection in such manner that we can turn the water on and break up the accumulation of sewage that collects here. About once every two weeks in inspecting sewers we go to this manhole and break up the scum and wash it down the sewer. This line has been in operation about two years and has not given any trouble. We deemed it best to have this lie this way than to have this section of the city using separate septic tanks that were also giving trouble.—McKean Maffitt, Wilmington, N. C.

Tool for Recovering Well Rods.—To those using deep wells as a source of supply with the ordinary deep well pump I have three suggestions which have been helpful to me in a number of instances. A tool for recovering lost rods from a well has been used successfully by our forces on several occasions. It is made of a 1-in. square iron bar about 5 ft. long. The upper end is fitted with a substantial iron ring, while on the lower end a heavy piece of galvanized iron, funnel shaped, is attached. The diameter of the bottom end of the funnel varies with the diameter of the well cylinder pipe, being about ½-in. smaller, while the upper opening in the funnel should be large enough to pass the pump rod freely, but small enough to guide it through an iron loop immediately above the funnel. The funnel should be from 8 to 12 in. deep. The loop is bolted to the iron bar about 4 in. above the top of the funnel and is 2 in. wide by 3½- in. long. This loop has a sharp chisel edge

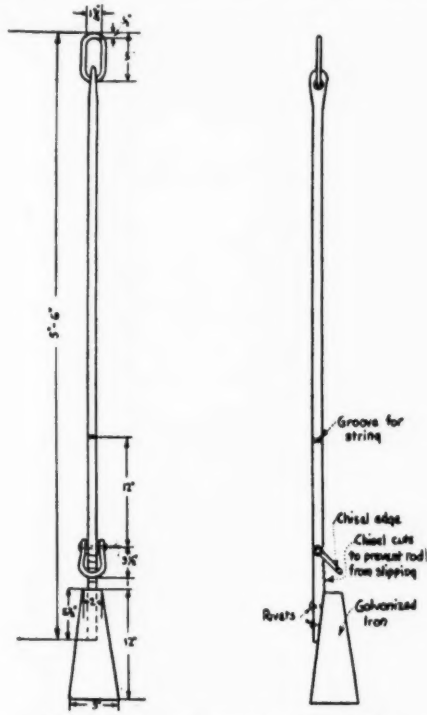


Fig 1—Tool for Recovering Well Rods

(Fig 1) to allow it to catch the pump rod securely. The end of the iron rod is tapered to fit the side of the cone.

The tool is used in the following manner. A rope, of sufficient strength to raise the lost rods and stand the added strain of pulling them through tight places while coming to the surface, is securely fastened to the ring on the upper end of the tool. The tool is then lowered into the well casing until the top of the lost rod is reached. As the lower end of the funnel is ½-in. smaller than the well casing, the upper end of the rod will pass through the funnel and the loop above it. The loop has previously been tied up with a cord, high enough to prevent the rod from passing on the outside of it, but not high enough to allow the rod to pass through it without taking the tension off the cord. The tool is now pulled toward the top of the well. The sharp edge of the ring cuts into the wooden rod sufficiently to raise the rod with it. The greater the strain put on the loop, the more deeply it cuts, and the more secure becomes the hold. Iron rods often may be caught by allowing the loop to pass below the first joint. By pulling the tool up again, the loop catches at the joint. This simple tool has saved considerable expense in eliminating the necessity of pulling the main casings to recover broken or uncoupled rods. We have successively raised twelve, 20-ft. rods with it.—Carl A. Heckmer, Salisbury, Md.

Tapping a Main.—In case you were tapping the main and should insert a corporation cock that was open you could not get the machine off the pipe without getting wet. I have done that very thing and got a good ducking from it. The next time this happened—and it will happen sometimes—I simply stripped the machine off the boring bar and

then cut off the water at the cock and removed the bar. If you be very careful, remove the collar from the top of the boring bar of the tapping machine, take the upper part of the machine off over the boring bar, then remove the lower part of the machine the same way, it will leave the cock in the main and the boring bar in the cock.—McKean Maffitt, Wilmington, N. C.

Plugging Small Holes in Wrought Iron Pipe.—Take a piece of soft white pine, taper it down to about the size of the hole in the pipe. Stick it in the hole and drive it in slightly. Draw it out and by examining the end that was in the hole you can get the exact shape of the hole. Now cut the stick so that it will have a slight taper and will be shaped almost like the hole in the pipe. Stick it in the hole and drive up rather tight. Be careful that you do not crush the stick, just tap it lightly until you have the leak stopped. Then carefully cut the stick off about ½ in. from the pipe and go home and to bed. That stick will stay there as long as the main does.—McKean Maffitt, Wilmington, N. C.

Red Water Troubles.—On Feb. 15th we appealed to the State Board of Health for help. The water was red, not only the hot water, but also the cold. The fire hydrants ran red—not slightly yellow, but red. Our first problem was to find out the nature of the compound in the water which was causing this red color. We analyzed the water and found it was iron.

We sent sample after sample to the Department of Chemistry at State College. I want to say here that his department will help any of you who need help. After analyzing the water or samples, they reported 100 per cent iron. We then took steps to stop the solution of that iron. The first thing we did was try to solve it temporarily by sodium carbonate. The results at first were terrible. There was much iron held in solution in the mains and in the city reservoir and sending up a neutral water or a slightly alkali water precipitated that whole mass all over our system. We had trouble getting it out.

The next problem was to remove the precipitated lime. We could not get the uptown department to flush, so we took the bull by the horns and went to the City Commissioners with our problem. They said, "Flush"—and we flushed for three weeks. We finally got rid of it and then waited three weeks and flushed again. Then we waited six weeks and flushed again and we have flushed periodically; each time getting a lower colored water, and now the water in the town is practically crystal clear.

We have accomplished this by the addition of only an average of ⅛ of a grain of lime per gallon. We are floccing the water at 5.2 and we have a hydrogen ion concentration of 6.8 which is acceptable from the standpoint of corrosion. However, that will require alum doses—3½ or 4 grains of alum. We are getting very satisfactory results now.—Mr. Hedgepath, Southern Pines, N. C.

Cleaning Clogged House Connections.—We have been very successful in relieving complaints of low pressure or insufficient supply in house connections, generally due to partly clogged piping, with the use of a small portable hand-pressure pump. A connection is made by means of a hose to the service pipe near the cut-off valve in the cellar and water is then pumped into the service pipe. Usually only a few quarts of water are necessary to pump the pressure up to about three times the pressure in the street main before the stoppage or accumulation of sediment will give way. It is usually not safe to pump higher, and if relief is not secured the service pipe must be dug up and replaced in the stopped section. Unless the stoppage is due to hardened encrustation, the force pump usually is effective. We always cut off the house plumbing so as not to subject any of the interior plumbing to the high pressure.—Carl A. Heckmer, Salisbury, Md.

Repairing Small Leaks in Steam Line.—If any of you run a steam plant and have a number of small leaks in your steam lines that are too small to shut down to repair, or are such that one of these patent clamps will not take care of, try this. Right at the boiler, in the horizontal pipe line, tap a small hole in the steam line. Insert a regular drip lubricator. Fill the lubricator with a mixture of cylinder oil and fine flake graphite. Make the mixture so that it will barely feed. Open the lubricator and let the mixture feed slowly into the line all the time. Attend this lubricator as regularly as you attend the lubricator on the main pump. In a few days you will fail to see any of those small steam leaks. The flake graphite will be carried into the crevices by the escaping steam and will effectually plug them up. If the graphite goes on over to the pump it will act as a better lubricator than the cylinder oil will. —McKean Maffitt, Wilmington, N. C.

Cutting Down Water Hammer.—In order to minimize the water hammer on our force mains we always close the discharge valves on centrifugal pumps slowly before shutting off the pump. However, when the pump is shut down suddenly due to accident, either the electric current failing or the power unit breaking down and the operator not having time to close the discharge valve, water hammer may cause serious damage. If the check valve holds, the main gets the full shock of the suddenly increased pressure, which on very long lines may build up to many times the normal pressure, and results in blown joints or cracked pipe. We are using pressure relief valves at our Burnt Mills Pumping Station which has a long force main leading from it. These valves are installed in manholes and set to open at fifteen pounds above maximum operating pressure. When water hammer builds the pressure up they open and prevent the pressure from going high enough to cause damage. We find it very satisfactory. With any emergency appliances care must be taken to keep them in operating condition. We operate these relief valves once each week to prevent them from becoming stuck.—Carl A. Heckmer, Salisbury, Md.

Kinks in Operation of Fire Hydrants.—Two especially simple operations are worth mentioning with regard to fire hydrant operation. Frequently a hydrant will open with difficulty during freezing weather, due to freezing of moisture in the stuffing box. Since all fire hydrants have a stuffing box the trouble can occur in any make. This usually can be overcome by tapping the operating nut with the hydrant wrench. The jar will free the stem from the packing and the hydrant will open with its usual ease. Especial care must be taken to see that the drain valve is functioning in freezing weather so the barrel will be emptied automatically each time the hydrant is used. Occasionally a stone or some clay will get into the drain hole and prevent drainage. We clear this kind of trouble by opening the main valve of the hydrant one full turn, leaving the nozzle caps on tight. As it requires about three full turns open on the main valve to completely close the drain valve on most makes of fire hydrants, the latter is still partly open on one turn. The full pressure of the water in the hydrant generally will push out any obstruction in the drain hole and the jet effect of the water through the hole will cut away the stone or earth which has packed around the outside. This simple remedy has eliminated the necessity of digging up the hydrant in most cases to correct drainage troubles.—Carl A. Heckmer, Salisbury, Md.

Locating Main Control Valves.—We have adopted the use of posts to indicate the location of main line control valves along roads in undeveloped sections where there are no houses or poles to measure from. A 3-in. pipe, 5 ft. long, capped on the upper end, is set in a small concrete base with 2 ft. bury. The body of the post is painted green and the cap light gray. An arrow and the distance to the valve is painted on the side of the post facing the valve. These valve posts are an advantage when the valve boxes are covered with mud or snow.

Repairing Blown Out Plugs.—Some years ago we had a regular siege of blown out plugs. In some few months we had five 16-in. plugs to blow out. In every case it meant shut down the plant until we could cut off the water. As our valves were not in good order at that time there was one case where we could not shut off the water tight enough to work in the hole. I got a common screw jack and some heavy gum packing. I cut a gasket 1 in. wide and the diameter of the plug, tied this gasket to the face of the plug with cotton string and then inserted the plug in the bell using the jack to force it to a seat against the gasket. This held the water tight enough for me to yarn and pour the joint. The hole was practically dry after I had jacked the plug up against the shoulder in the bell. I have used this trick several times and each time it works easier than it did the first time.—McKean Maffitt, Wilmington, N. C.

Remedies for Red Water Troubles.—Dunn had complaints from all over the distribution system of red water. When I got down there the trouble had disappeared. The Dunn plant is not run by laboratory adjustment, the operator simply adjusting his alum and alkali until he gets a floc. In looking over the records of the State Laboratory at the time of this red water trouble, we found that the water at that time had a pH around 5.6 and the same conditions that Mr. Hedgepeth just mentioned. Of course, the logical treatment was the secondary alkali to bring that pH up to neutral. When I went there we found that the pH had gone back up to 6.8 and the operator had succeeded in getting a floc by using four grains of alum to the gallon and then lime with it. This was a new plant and new filtered supply. Whenever they had to coagulate the water to get a low pH they had red water and as soon as it was possible to get a floc with pH up to 6.7 or 6.8 the red water disappeared. The recommendation was to put in a secondary alkali feed. However, they did not have that available and it was a question of providing equipment for it or using a larger amount of lime to keep the pH up and prevent red water trouble.

Another case was at Fayetteville at the old plant before it was rebuilt and there were proper facilities for getting proper operation there, we knew that lots of water went through that was not properly coagulated. In analyzing the scale there we found some evidence of aluminum hydrate mixed with it. The red water persisted. I think that red water persistency in the mains is due to the fact that there is corrosion in the mains and the scale more or less adheres to the inside of the pipe and that is gradually loosened up and washed out and it takes some period of time before you can get rid of it.

The last case was Asheboro. Asheboro has a brand new storage reservoir—a new reservoir with a lot of vegetable matter in it. That may have had something to do with the water that could be floced at a low pH and similar to the colored water in the eastern part of the state. We found in Asheboro it was not possible to get the floc unless we used alum alone and a pH reaction of 5.6. The remedy there was the installation of a secondary dry feed and with this provided, the trouble is beginning to clear up. I noticed particularly as Asheboro the carbon dioxide is very high—about 20-27 p. p. m. and when they brought the pH above 7.0 it reduced the carbon dioxide down to almost nothing.

I am very positive that with some of the eastern waters where the normal adjustment is below 6.0 pH that there is corrosion, in fact they have had some complaints but not such serious manifestations of red water as at Southern Pines and Asheboro. As a matter of fact I think that some superintendents have slightly red water in the mains frequently and have reached the point where they think there is no remedy for it and just have to put up with it and take it as a matter of course. I believe that this readjustment of the finished water up to a suitable hydrogen ion concentration value will prevent this corrosion and is an order of procedure well established.—G. E. Catlett, Raleigh, N. C.

Tool for Recovering Well Cylinder.—Another simple tool has been used several times for raising pipe out of a well when the pipe has been dropped. The farther down the end of the pipe, the more the patience required to enter the

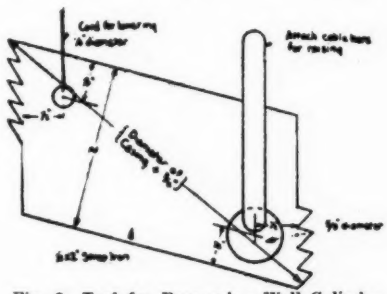


Fig. 2—Tool for Recovering Well Cylinder

tool, but once entered it will catch hold and bring out the pipe. It is made of ½-in.x2-in. strap iron in the shape shown in Fig. 2. The diagonal measurement "A" must be about ¾-in. longer than the diameter of the pipe to be raised. A cable of sufficient strength to raise the lost pipe is attached to the tool through a ring on the lower side and a strong cord is attached to another hole on the upper side. This string serves to hold the tool in a vertical position for entering the pipe. After the tool is properly entered, the pull is made with the cable, the string being allowed to remain slack. It is of course necessary to have the teeth as sharp as possible. The tool becomes wedged across the pipe and raises the pipe to the surface. If the water in the well does not stand too high or the lost pipe is not very far down, light can be reflected into the well and the tool easily entered. If this is impossible, the depth of the top of the lost pipe must be determined and the tool let down beyond this depth.

We always drill a small role in the inner casing of a well about 4 or 5 ft. below the ground surface. This allows the water to drain out of the pump in case it is shut down during freezing weather and no heat is provided. This drain is automatic and wastes very little water while the pump is running. This arrangement is a decided advantage where pumps are allowed to run all night unattended during freezing weather when the pump may stop and freeze up before morning.—Carl A. Heckmer, Salisbury, Md.

Repairing Cracked Mains.—Some years ago I had a leak reported on a 12-in. main. When we opened up on it we found that the spigot end of the pipe was cracked. The crack ran about 18 in. out of the bell. Rather than cut this section I used two clamps made of ¾-in. by 2-in. flat iron. These clamps were made in two sections, one-half circle in each section, with 3-in. lugs on the ends and 1-in. hole bored in each lug. The whole clamp is made so that it is a snug fit with about 2 in. clearance between the lugs when it is placed around the main. Use long threaded bolts through the holes in the lugs, drawing the clamp further away from the bell tight first, then tighten the next clamp. As you start to tighten the clamps, if you will take two light round pien hammers and lightly tap the pipe just on each side of the crack you stand a better chance of getting a good tight joint, as the vibrations of the hammer blows cause the ragged edges of the iron to seat together more evenly.

In case the crack happens to be in the body of the pipe and not at the end, you can do the same thing. Though it is better to start the two end clamps first, working gradually toward the center—that is, if it requires more than two clamps. The clamps should be spaced about 8 in. to 12 in. apart, depending upon how bad the crack is. If the crack is ragged and uneven there is no chance of making a fit. If the crack happens to have been caused by a blow from a pick and the pick stuck through the main, work the crack up the hole caused by the point of the pick and then put a heavy lead gasket over the hole and a clamp over the lead gasket and draw the clamp up tight. Of course you will get wet and all these cracks will happen in the winter time and at night, but then it is easier than to cut out a section and costs about one-fifth as much.—McKean Maffitt, Wilmington, N. C.

Reading, Billing and Collecting.—We use a postal card system and we read and bill every day. We have two meter readers that don't do anything else but read meters and re-read and check up and inspect. They read about 200 meters a day and in the evening they turn in their cards. The next morning a girl makes out those bills on a Burroughs billing machine using postal cards and the bills are mailed that afternoon. The bottom of the bill carries the notice to bring the bill when paying. If the bill is paid by check, there is a notice to detach the stub and forward with check. There is also a notice that the bill is now due and must be paid within ten days.

We send out 200 bills each working day of the week. We collect about 200 bills each day, so we have a constant flow of work. If a person comes in without the bill, we make them go to the second floor to get a duplicate. That means a person has got to walk up a flight of stairs. Very seldom do you find people coming in to pay their bill the second time without having the original bill which we sent out.

Recently we had to make some alterations to the first floor and we had to move everything to the second floor. We have had a lot of complaints about making people walk to the second floor to pay their bills—more complaints about that than anything we have done in the last nine years.

Instead of using sheets, we use the card system—6x8 in. ledger cards. The bill is made out from the original read-

ing of the meter reader. The bill that is prepared is recorded on the ledger cards.

At the end of ten days when these bills are not paid, the young lady takes the routes that were read ten days previous and goes through them and makes out a final notice. That is made in triplicate. A copy is mailed to the consumer. The government does not permit you to mail a dun on a postal card, so that notice has to go out first class. On this notice is the statement which is not exactly a threat, but almost so, that if the bill is not paid within five days the water service may be discontinued. We don't want to say it will be, because that is a direct threat. We allow them 48 hours after that five days, so if they should mail a check we will receive it. If a letter does go astray and we should turn the water off, we return the fee if the postmark is within the limit allowed.—J. E. Gibson, Charleston, S. C.

Joint Sleeve.—We installed a line of Universal pipe some time ago and the foreman in charge was a little skittish about the joints and had them pulled up hard and tight. About three years after installation trouble began to develop in every cold spell. We found that in taking out a broken section we were lucky if we got by without breaking at least five spigot ends—thus there was always 25 ft. of pipe that was wasted. That being too expensive, I had these flanged sleeves made and in case we have a Universal joint that leaks we put this around the joint, bolt it tight onto a lead gasket, yarn and pour the same as we would any other joint, and that is the end of our trouble. About a week ago we had a 6 in. B. & S. line to slump off the side of a hill and pulled a spigot so far out of the bell that you could stick a pencil into the joint. As it was impractical to straighten the line up just at that time, we tried one of these joint sleeves and it worked so well that for the time being we have left the line just as it was.—McKean Maffitt, Wilmington, N. C.

Turning on Water.—Our rule is almost universal that if a man is not an owner of the property he must make a deposit of at least $5. We pay interest on that deposit. We find that if a man moves, he is just as jealous of the $5 as he can be and he doesn't move until he comes down and gets that $5 back with interest.

If a meter lays idle for two weeks, we take it out. Of course, it costs us something to take a meter out but we bring it to the office, put it on the test table and if it tests all right, we simply put it back in stock to be used again. If for any reason it does not test satisfactorily or the meter inspector has reason to believe that the meter should be cleaned, the meter is then cleaned and put in good shape. We have found there is quite a saving in that because it overcomes the trouble of a plumber turning on the water and leaving it turned on.—J. E. Gibson, Charleston, S. C.

Plug for Testing New Mains.—By W. L. Weaklend, Superintendent of Water and Lights. Our city ordinances provide that an addition to the city shall be put to grade and have water and sewer mains installed before it is accepted by the city. We have had two blocks of 6 in. C. I. pipe put in to comply with this ordinance in the last few days.

Property owners pay all expenses for water services from the main to the property or house. Extra strong lead pipe

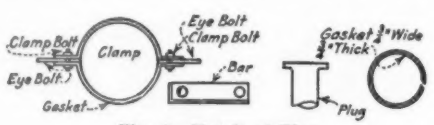


Fig. 3—Sketch of Plug

is laid to the curb stop, which is placed within 1 ft. of the side walk, in the parking.

In putting in the two blocks of the cast iron main we do not allow the contractor to cover up bells until the joints are tested out for leaks.

We test out every block and inasmuch as we do not put a valve every block we have to use a test plug. Heretofore we always had to either put in a plug with lead, the same as any other joint, or a plug that was supposed to screw out of the joint.

I very soon saw that this was not very practical so I had a clamp made to fit the bell of the pipe. I also had two eye bolts made so that you could put the bolt that holds the clamps together through the eye bolt when you put the clamp on the bell. I also had a bar made to go from one bolt to the other, this bar also had holes in it for the eye bolts to go through. The purpose of this bar is to go across the plug which is put in the ball. I made a gasket out of some packing that we use to pack our triplex pumps with. This gasket is soft and pliable so as to take up the pits and slight raises that may be either on the bell or plug.

The plug that I use is the style where the head of the plug goes in the bell. In installing this test plug you first put your clamp around the bell with the eye bolts in place, then you see that the bell is free of dirt or other particles before putting the gasket into the bell; then place gasket and see that the plug is free from frozen dirt, asphaltum or tar on the face that goes next to the gasket; then put plug into place against gasket, then put the cross bar across the plug with eye bolts; through same put nuts on eye bolts and tighten up.

This plug only takes about 5 minutes to put on and from 3 to 5 minutes to take off and saves the inconvenience of melting out the old style plug.—W. L. Weaklend.

Painting Hydrants.—Hydrants should be painted occasionally, to protect them and for the sake of appearance. We find that once a year is not too often to do so. The color scheme is a light gray barrel with a dark green top. The light gray barrel shows up very plainly at night. In the day time there is also a decided contrast against the green hedges and grass parkings which predominate in our area. The dark green top makes it easy to spot the hydrant when snow is on the ground and yet the green color blends with the landscape and is pleasing to the eye.—Carl A. Heckmer, Hyattsville, Md.

Hydrant Records.—Hydrants are inspected three times each year, in early fall, winter and spring. Flushing is done in the fall and spring but not in mid-winter because of the formation of ice in the streets. A record of the inspection, nature and cost of each repair is kept on a card system, but for quick reference we have originated an idea which has been highly commended by the Fire Underwriters' engineers. We use a map, made on a 600 ft. scale, mounted on wall board for this system. A push pin shows the location of each fire hydrant. The color of this pin denotes the condition of the hydrant, blue being used for a hydrant in good condition, black for a hydrant which is in need of minor repairs, but still operative in case of fire, and red for a hydrant which is entirely out of service. We, of course, make every effort to keep all blue pins on the map, but a red pin is rarely left on the map over night and then the local fire department is notified. When a hydrant is reported out of service, a glance at the map shows whether all the hydrants immediately around it are in good condition. As many different makes of hydrants were used on the several systems acquired by the Sanitary District, it is an advantage to know the make of hydrant before sending out a repair gang so the proper parts may be carried along. By using small round colored discs under the push pin we can determine at a glance the make of the hydrant, a different color of disc being used for each make of hydrant. Small celluloid flags are used to show the date of the last inspection in the various areas. The dates are written on the flags in ink and can be easily washed off and corrected with each subsequent inspection.—Carl A. Heckmer, Salisbury, Md.

Patching Cuts in Paved Streets.—In patching paved streets where there is a dense traffic and it would be inconvenient to leave the hole blocked off for some time while the concrete set up, I tried the following method: Tamp the hole until it is solid as you can make it. Make a mixture of concrete the same as usual only not so wet. Make it the consistency of stiff putty. Put this in the hole and tamp it hard. I mean hard, not just light taps. Tamp it until it is almost impossible to make an impression on it with the tamping iron. Put your top surface down on this tamped concrete. Bricks, sheet asphalt, Hastings asphalt blocks, Kentucky Rock Asphalt or any other kind of surfacing. Cover the finished surface with about 1 in. of loose sand and open it to traffic. Nothing short of a 10-ton load will affect it. There are about fifty such places here in Wilmington. It worked out so well that even on those streets where there is very little traffic we do the same thing. We never block off a paved street for the regulation ten days. Only just so long as it takes us to put in the material.—McKean Maffitt, Wilmington, N. C.

How to Beautify Grounds Surrounding a Water Works

The following simple landscape principles by Jas. D. Fowler were abstracted from *Municipal News and Water Works*:

One thing which has been greatly neglected around water works plants is the beautification of the surrounding grounds. It is a thought worthy of consideration by public officials, or any tax-paying citizen.

Why Water Works Grounds Should Be Beautiful.—Water works grounds should be beautified for psychological reasons if for no other. Beautiful things or surroundings suggest purity.

A water works is only one of the several utilities which should be given the beautification treatment such as will be outlined in this paper. Electric light plants, gas plants, ice plants and sewage disposal plants should be given equally as much attention.

The general opinion is, especially in the smaller towns, that to spend money for beautification is a waste of money, that the water will not be made any better thereby and that the revenue of the plant will not be increased. We may have to admit that there is no direct benefit derived but there surely is an indirect benefit. A well cared for and beautified water works plant is sure to be seen by someone and possibly many who in turn will tell others and the result will be advertisement for the town.

It may be that the city officials will say that there are no funds for such a purpose, but the real difficulty is with such officials that they have not been able to visualize and see the beauty in nature. It is wonderful and marvelous the progress which has been made in the manufacture and development of machinery but such is as of naught compared with the things of nature. When we see the seed planted in mother earth and it bursts forth into a beautiful flower or shrub then that is something to marvel about. When a little landscaping is done we are getting back closer to nature and the things that are beautiful.

Too often we find that a water works plant, especially those owned by a municipality, it is the business of everybody, hence nobody's business. The writer has observed generally, that privately owned plants are given more attention along beautification lines than are muncipal plants.

Chief Operator Not to Blame.—The chief operator of a plant cannot always be blamed for lack of attention along beautification lines and is ofttimes not recognized in his effort to accomplish something. When he applies for financial assistance the city council or authorities do not appreciate the value and necessity of such expenditure and he is turned down in his request. This disgusts the operator, he resigns and then is probably replaced by an incompetent man who will not worry them and who can be employed at a modest salary.

One who expects to accomplish something must realize that the road is not always smooth. He must have that sticktoitiveness and educate the public and more particularly the city authorities with whom he has to deal. He can do this by keeping his plant clean and on a small scale begin to beautify the grounds. He can get some of the citizens to visit the plant and appreciate what is being done and from then on enthusiasm and interest will grow and out of town friends will be invited to visit the plant.

Beautification a Separate Problem for Each Plant.—The landscape development is a distinct problem for each individual plant. The ideal way to proceed would be to employ a landscape architect to prepare plans and make suggestions for the improvement. This, of course, would require an outlay of cash and this, as has been pointed out, is very difficult to secure.

Also, as has been said, the work can be begun in a small way. It is not necessary that the entire work be done or anything elaborate be accomplished immediately. If you will stop for a moment and think what small job it would be to smooth off the rough places or slopes and sow some grass seed, or in southern sections, spot a few pieces of bermuda grass, you would not be long in starting a beautification program around your plant. Water is very necessary in an undertaking of this kind, but the subject we are dealing with being water works would indicate that water was no object.

General Plan of Development.—It is well for the operator who determines to accomplish something along this line to have in mind the following principles which will be outlined, and to prepare in his own way a general plan for the development which he can execute from time to time and gradually expand.

The operator should make a rough map showing the relative locations of the various features on the ground. He should secure sufficient information in regard to the levels to properly drain the grounds and, on this plan sketch out the various features to be added with their ultimate position. He should give general consideration to the grading, driveway, walks, shrubbery, planting, and on more elaborate plans, he would probably go into the matter of flower beds, garden furniture, seats and other features.

Driveways and Walks.—In laying out the general plan one of the first questions will be the driveway, provided the grounds are so situated as to require a driveway. The purpose of the driveway is ingress and egress. It should serve its purpose quickly and be as direct as possible; it is not in itself an ornament but is a utility. On large grounds, it may be one of the functions of the driveway to permit passage through the grounds for the purpose of viewing other features more distant. In such case it may be expanded over greater areas.

The width should be ample, but not excessive. The directions should always be simple and apparently direct. Unnecessary curves and turns are only awkward, not beautiful. The driveway should be located so as not to cut up lawn spaces unnecessarily but should be fitted to the topography and gracefully curve around the existing natural features. If there are no existing natural features, it may be necessary to design a planting of trees or shrubbery to give reason for the desired changes in direction . It is not proper to use a small flower bed, or a small architectural object, or other such things as they are too trival. The driveway should be from 9 to 10 ft. wide for a single drive, and from 16 to 18 ft. wide for a pass drive. A 12-ft. drive should never be used. It is too narrow for two vehicles to pass and unnecessarily wide for one. There is no beauty in paving surfaces; lawns are to be more desired than the barren driveway.

It will probably be unnecessary to speak of drainage, materials for construction and construction features such as excessive grades, etc., but they should be considered, of course, in a practical manner.

Walks and paths are designed and built on the same determining principles as driveways; there should be some reason for their being, as for instance, to lead to a gate, a door, a seat, or some other feature. The construction is also similar to driveways. On steep grades, steps can be worked in to advantage; also an opportunity to show originality on the design of butresses, walls, etc., is here given. Where a path is seldom used or where a solid walk threatens to cut through a lawn, stepping stones are desirable, set in so the lawn mower will pass over them.

Use of Shrubbery Beds.—Shrubbery beds are used to screen off undesirable views and angle points, border division features and for foliage effects, etc. Shrubbery beds should be shaped to conform to the purpose and location of the bed. The ground plan of the planting should show prominent points and deep bays. The extent of a particular section may be apparently increased by the appearance of distance made by a plantation bay. In planting, strive to get simple, broad effects instead of startling, unusual ones. It is better to secure more restful and peaceful results and impressions than unnatural effects.

Plan to plant in groups and masses rather than in spotting the lawn with individual shrubs. A lawn in which the shrubbery is spotted in individual specimens seems to be much smaller than the actual dimensions, while a lawn with an open center and the shrubbery grouped on the border will have just the opposite effect, and will give the effect of spaciousness. A single row of trees or shrubs for a screen is not so good as a broad mass planting. In planting a group do not arrange the plants in rows or tiers. It is a good plan to observe how Nature masses the shrubs by intermingling the various trees and shrubs. This does

not mean that the plants should be shuffled and placed in a haphazard fashion. Observe the natural groups and you will find character and pleasing effects. Nature enables sturdy plants and trees to stand out above the remainder. In planting in groups, individual plants scattered throughout the groups and separated from one another does not give a natural effect. There should be several of each kind of plants in a group and the groups should be blended into other groups.

Balance in Symmetry.—The human eye naturally seeks balance in symmetry. In Nature the idea of balance about some common center is evident. Do not take this suggestion too literally and duplicate individual shrubs about a common axis, but use shrubs of similar habits and similar positions, although not necessarily identical positions. It is not necessary that expensive nursery grown shrubbery be used. It is, of course, more desirable and convenient, if nursery stock could be secured, but very often it is possible to secure native shrubbery from the adjoining woods which, when properly transplanted and cared for, will respond and create some wonderful effects.

Since landscaping is more or less a sideline of mine, I will let you in on some of the secrets of the business. For instance, you are probably all familiar with the so-called buck bush which grows promiscuously in the woods. It is a very simple matter to transplant these successfully with practically no cost. However, when a landscape architect handles the buck bush for the client the name is changed to symphorycorpusresmorus and the cost of the plant is from 10 to 25 ct. each.

The introduction of some pointed pyramidal shrubs or trees, such as lombardy poplars, at salient points gives character and adds interest to an otherwise monotonous planting. Trees should be placed at desirable points for shade and to form vistas. Good judgment should be used in the planting of trees so that, as they grow, they will not interfere with the operation of the water works plant.

The Importance of the Lawn.—There is no feature of landscape planting which is more important to the successful beautification of property than a beautiful lawn. Its importance is seldom appreciated and too often the lawn is not properly considered. It is the foundation and background upon which the various features are placed to form the picture. It harmonizes and ties the various features together with pleasing contracts. A good lawn is similar to a well dressed person; it is not conspicuous unless deficient. Brown or unburnt spots or weedy patches attract attention to the lawn and minimize the effect of all other features. The lawn will respond readily to treatment and attention.

Too often a lawn is expected to grow on excavated clay and shale or on a thin layer of soil covering piles of rock and building debris. A properly prepared loam bed will repay many times the extra trouble necessary, when the drought comes late in the summer. The grading of the lawn, apparently is a very simple matter, but is very important to the final appearance.

The topography should be carefully studied and a contour of the lawn should form an integral part of the landscape. It should blend from one elevation to another without abrupt change. A perfectly level piece of lawn with informal and irregular surroundings is entirely out of place. Long, flowing, sloping lines should be maintained. This will also enable the lawn mower to be more easily operated and the lawn to be kept in better condition.

Location of Flower Beds.—It is poor practice to put flower beds or rose beds in a lawn in every conspicuous place. They should be placed along the edges of the shrubbery border in convenient protecting bays. The shrubbery forms a good background and a frame for the blooms, and the maintenance of the grass edges around the flower beds is reduced to a minimum.

Roses are beautiful when in bloom, but in other seasons they are an unsightly group of briers. The best place for roses is a separate area grouped in a rose garden, or along fence or trellis. Roses will do better when protected from strong winds than when set in an open lawn.

For the extensive and elaborate grounds other features may be worked into advantage. Seats conveniently placed are very interesting; pergolas, monuments and statuary all have their place and can be worked in from time to time.

Water Works and Sewerage

H. P. GILLETTE, Editor

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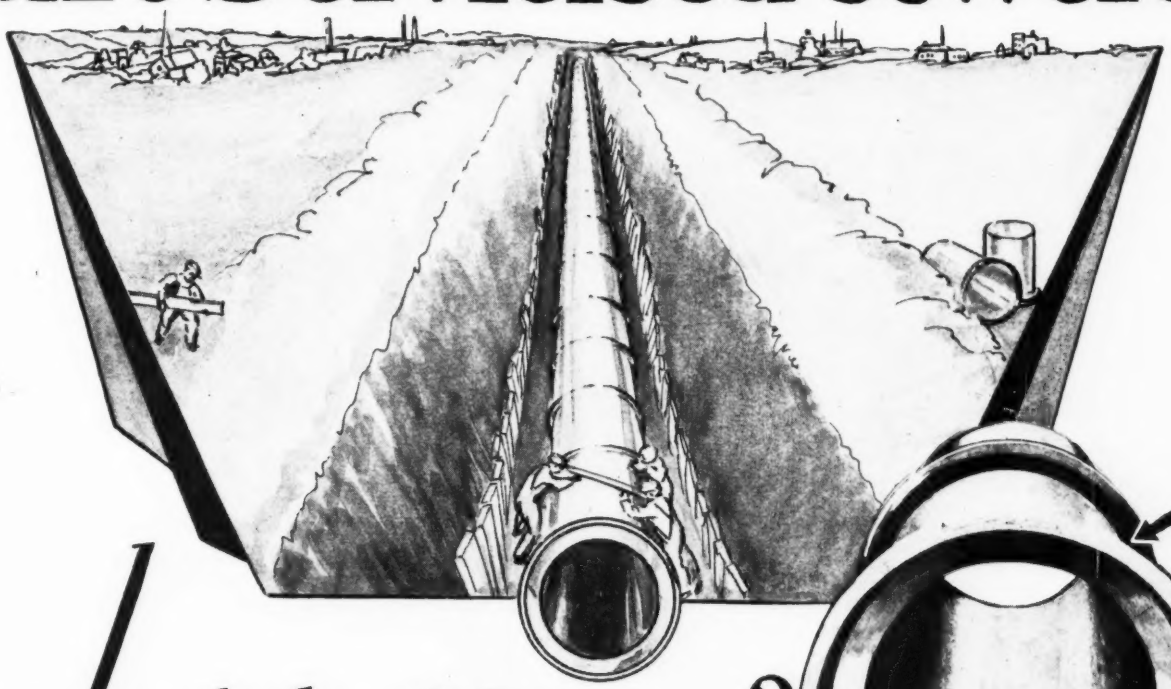

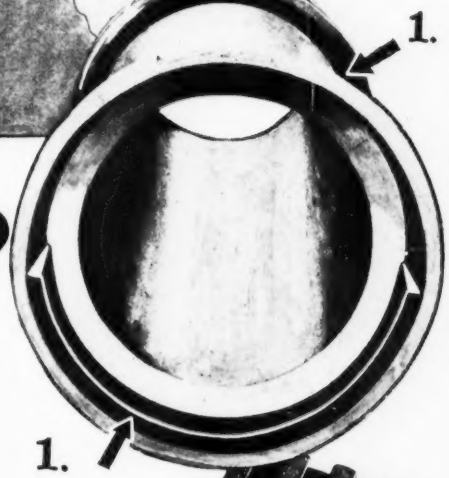

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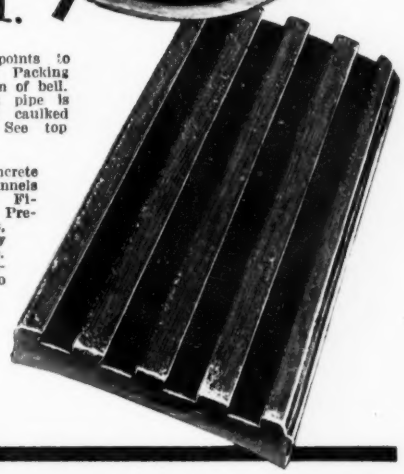

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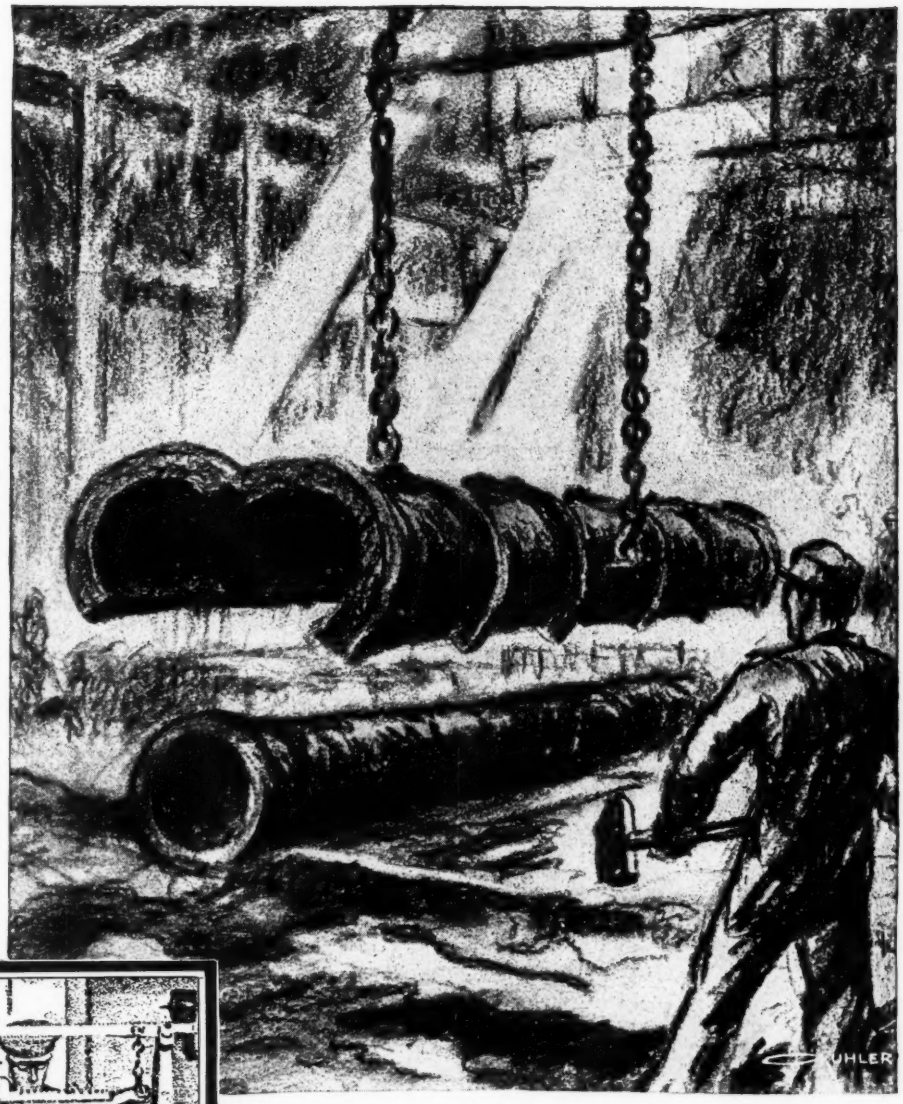

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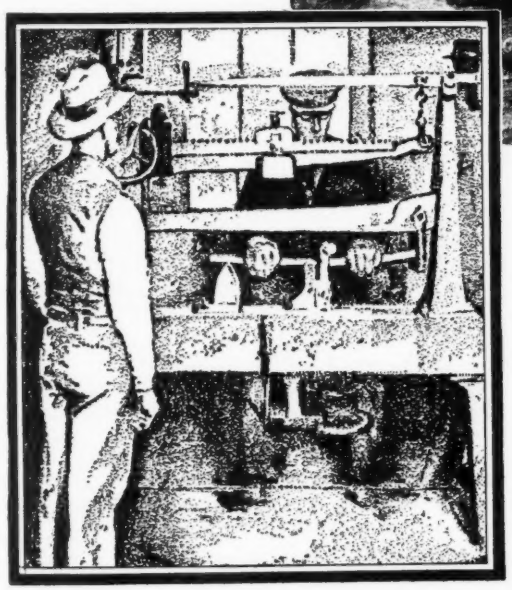

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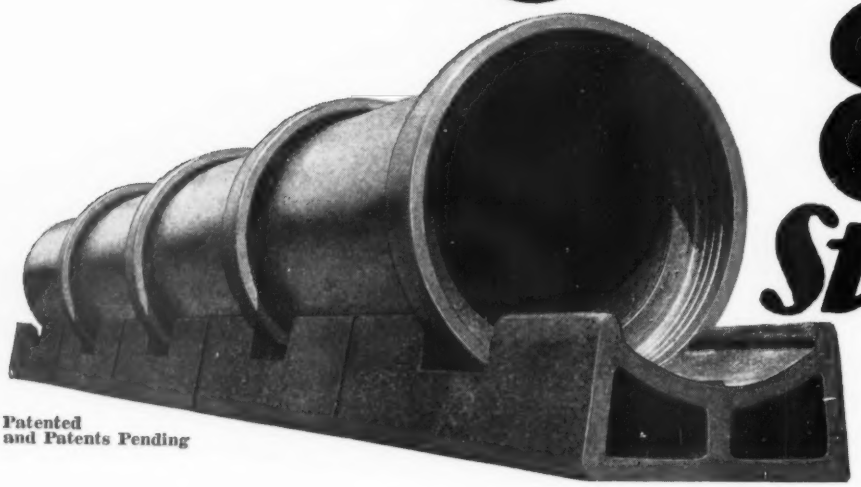

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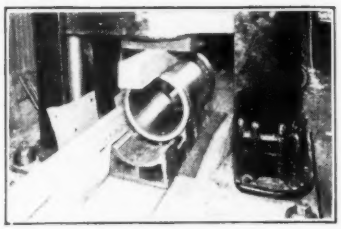

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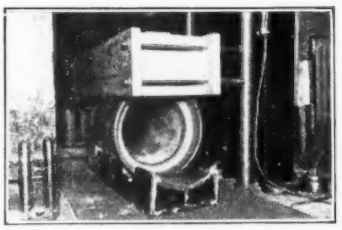

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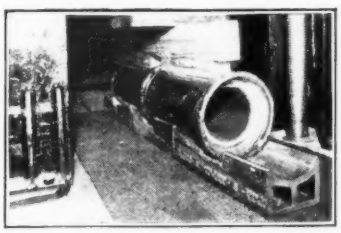

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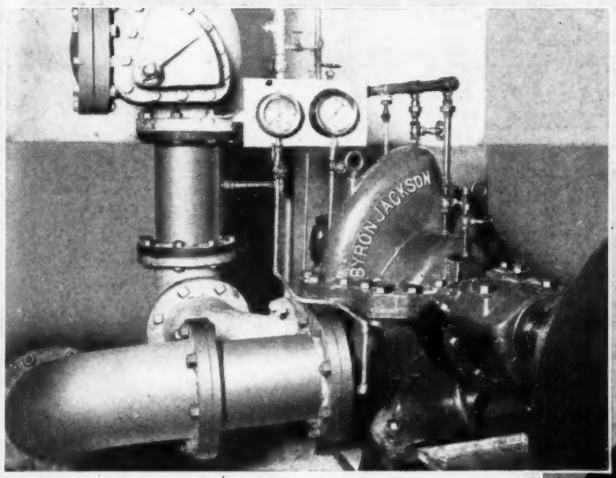
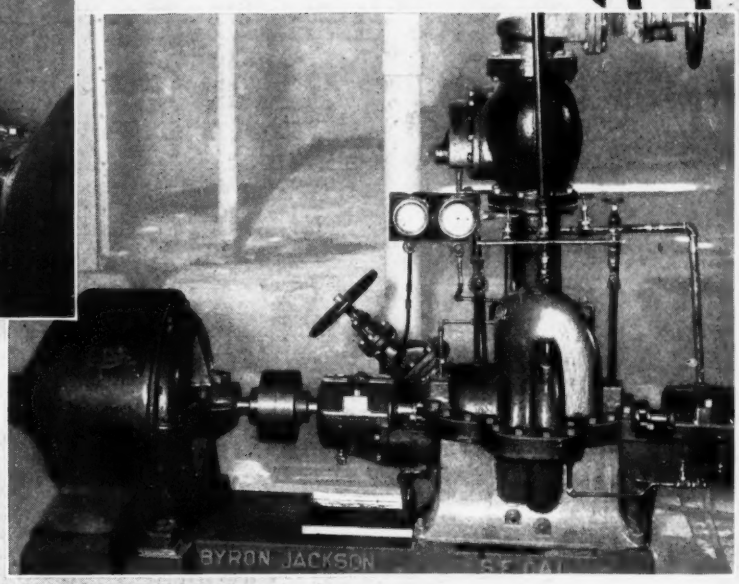




Byron Jackson Multiplex Pumps are shown delivering water direct from bored wells into city mains. Ordinarily deepwell turbines are installed to raise the water from the wells and discharge into a multiplex pump for the necessary pressure boost into the mains. In the locality in which these pumps are installed the water table remains practically constant and there is no danger of the water falling below the suction reach of the pump or rising up and flooding the pit. Wherever such water conditions prevail, Multiplex or Type "S" Centrifugal Pumps in the pit make an excellent installation.

SINCE 1872

BYRON JACKSON CO.

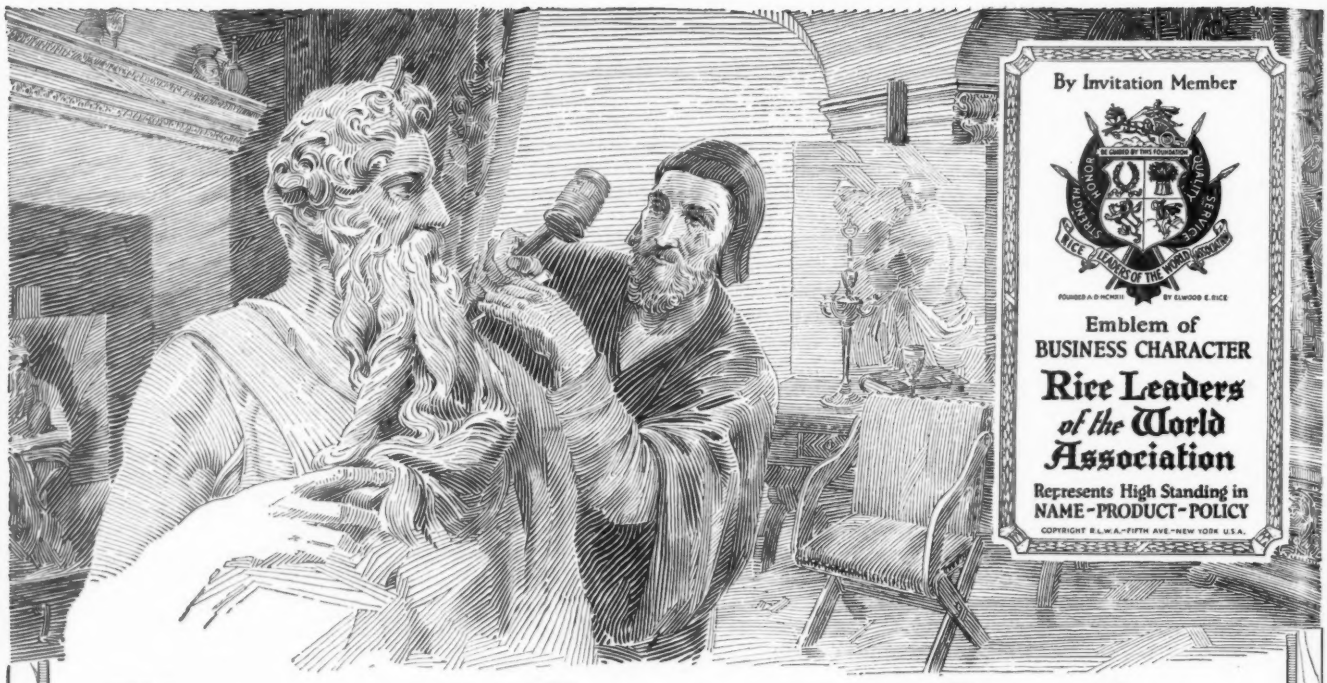
Factories: BERKELEY, Los Angeles, Visalia, Calif.

Branches: NEW YORK and CHICAGO

San Francisco, Portland, Salt Lake, Tulsa, Dallas, Phoenix

BYRON JACKSON

CENTRIFUGAL PUMPS FOR EVERY SERVICE



Character Protects Quality

Your best warrant of the Quality of ANY merchandise is the character of those who make it.

Take Michelangelo for example: If a statue or painting failed to meet his exacting standard of quality, he abandoned the work or destroyed it.

Thus men of integrity always protect the quality of their products. In the manufacture of "DARLING" Gate Valves and Fire Hydrants, this especially holds true.

For here, in our modern factory, there are men of character in every department—men who protect YOU, and protect Us, by seeing that high standards of quality are faithfully maintained.

Because of this, and because of the DARLING VALVE & MFG. COMPANY'S long-established reputation, we are "by invitation" members of the Rice Leaders of the World Association. No more conclusive evidence could be offered that a manufacturer combines high grade materials with fine workmanship and straightforward dealings.

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DARLING
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BUILDING FOR A GREATER TOMORROW

Up goes your dipper—steadily, surely, relentlessly forcing its way through solid earth that breaks and crumbles, rolls and tumbles — while spectators gather, fascinated and awed.

In a thousand and one places, in many lands, the constructors of today are digging — building for a greater tomorrow! And depending on Bucyrus-Erie shovels for unfailing performance.

World leadership of this half-century old organization is based, first of all, on a true knowledge of the equipment needs for each and every excavating job. Knowing these needs, Bucyrus-Erie has developed each machine to do the special work it is built for — maintaining in each the proper distribution of weight, the correct application of power, and the true relationship of every part that must exist for dependable, low-cost operation and long service.

Small shovels, large shovels — any type for any job — Bucyrus-Erie builds them all. And follows each sale with world-wide service!

SEE US AT THE ROAD SHOW — SPACE 214

Power shovels, clamshells, cranes, draglines, dragshovels — ½ to 16 yard capacity — electric, steam, gasoline, Diesel, gas + air, Diesel + air.
Dipper, hydraulic and placer mining dredges. Tower-excavators and Railway cranes.

A-7-12-29 WWS

Tell us about your job—and let our engineers make recommendations.

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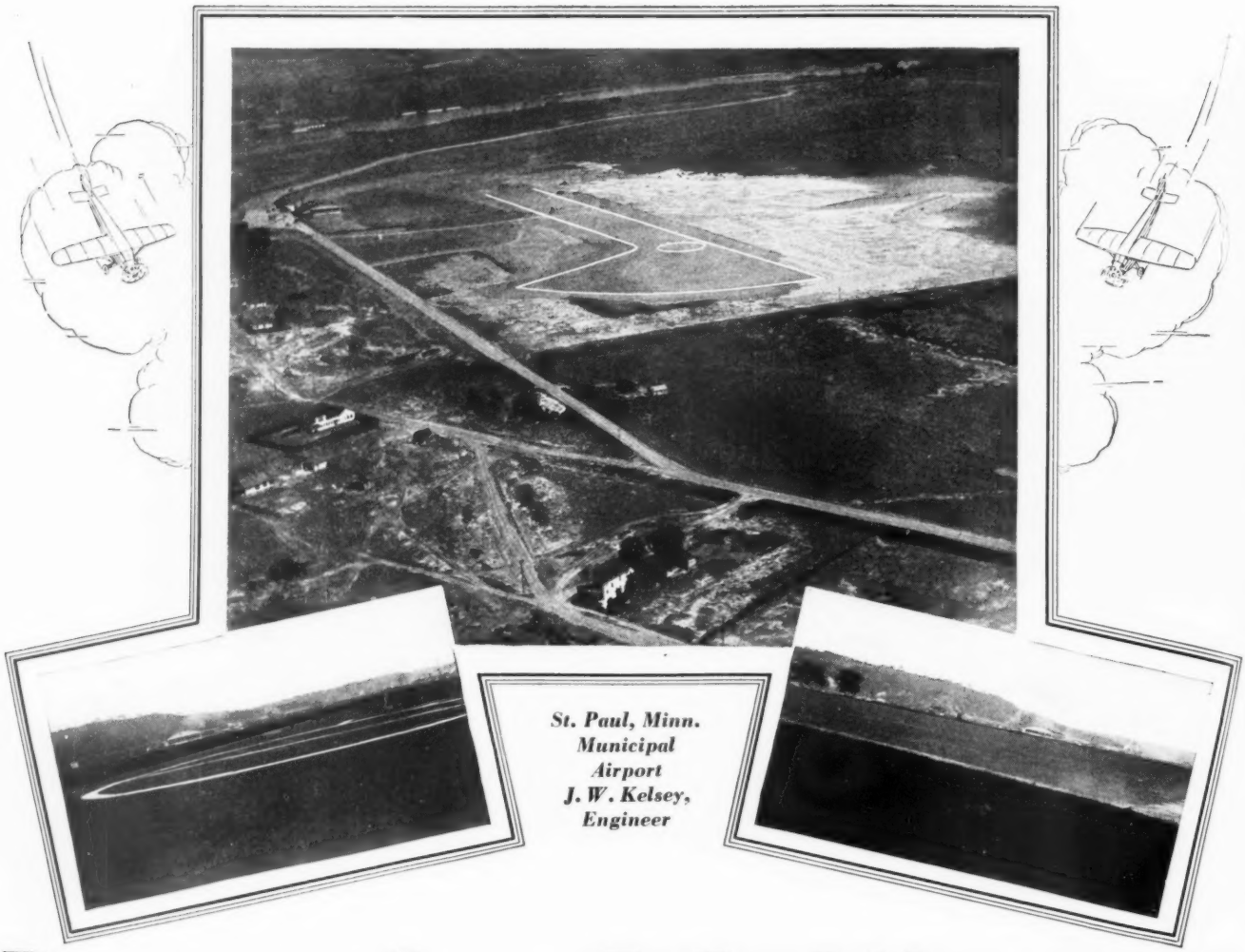
Branch Offices: Boston, New York, Philadelphia, Atlanta, Birmingham, Pittsburgh, Buffalo, Detroit, Chicago, St. Louis, Dallas, San Francisco.
Representatives throughout the U. S. A. Offices or distributors in all principal countries.



St. Paul, Minn. Municipal Airport J. W. Kelsey, Engineer

Runways of new St. Paul Airport are built with Stanolind Paving Asphalt

The new Municipal Airport at St. Paul, Minnesota, will be, when completed, one of the finest of its kind in the country, having a hydroplane bay as well as a landing field.

In the building of the runways, Stanolind Paving Asphalt was used. The construction consisted of 2 inches of Hot Mix Asphaltic Concrete on Penetration Macadam or Black Base.

This is the highest type of runway paving

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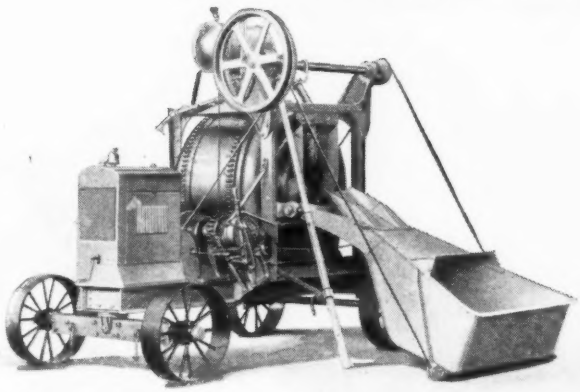
KOEHRING experience, Koehring Heavy Duty construction, are two of the greatest profit factors you can put on the job!

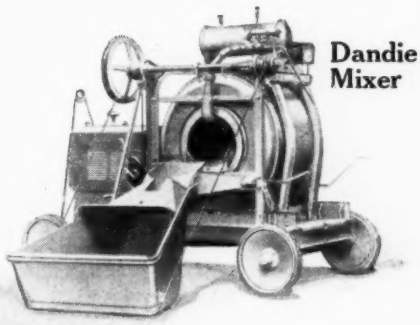
Koehring equipment is sold through organizations that are *service* as well as sales organizations!

Again we say *"Know the Koehring!"*

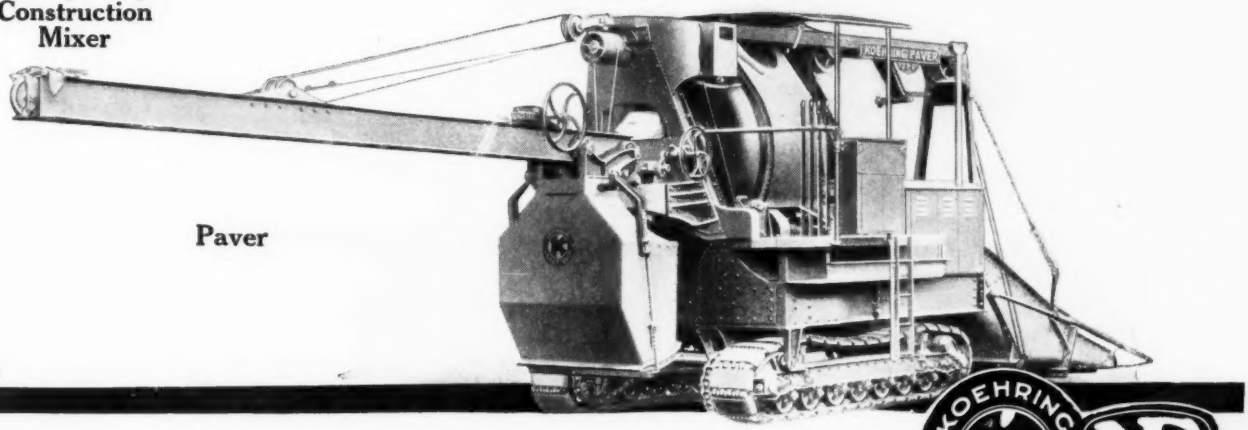
Write for Bulletin No. 9 on any of the machines interested in.



Heavy Duty Construction Mixer



Dandie Mixer



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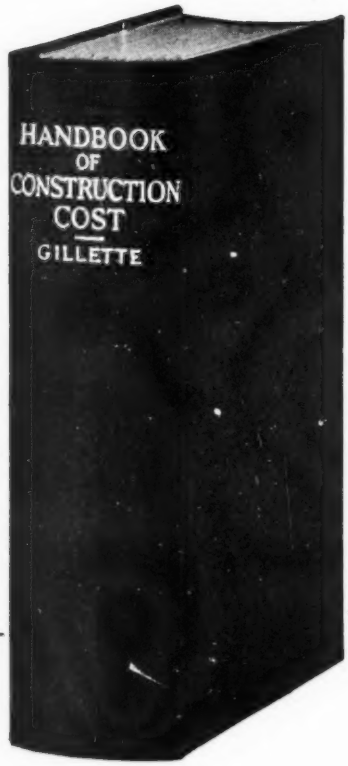

When you get a chance to estimate on one of those jobs you feel you've just got to get —you'll find a world of comfort in turning to H. P. Gillette's "Handbook of Construction Cost." Solid facts, complete reliable data right at hand! That's what gives a man the confidence to produce a "sure fire" estimate.

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See the Range of Work on Which Data Are Given

Engineering Economics—Prices and Wages—Hauling — Excavation Economics — Concrete Construction—Dams, Reservoirs and Standpipes—Water Works—Water Treatment Plants —Irrigation—Land Drainage—Sewer—Sewage Treatment — Garbage Disposal — Street Sprinkling, Cleaning and Snow Removal—Roads and Pavements—Highway Bridges and Culverts—Railway Bridges—Steam Railways —Small Tunnels—Large Tunnels—Bank and Shore Protection — Docks and Wharves — Building Construction—Engineering, Surveying and Overhead Costs—Miscellaneous Costs.

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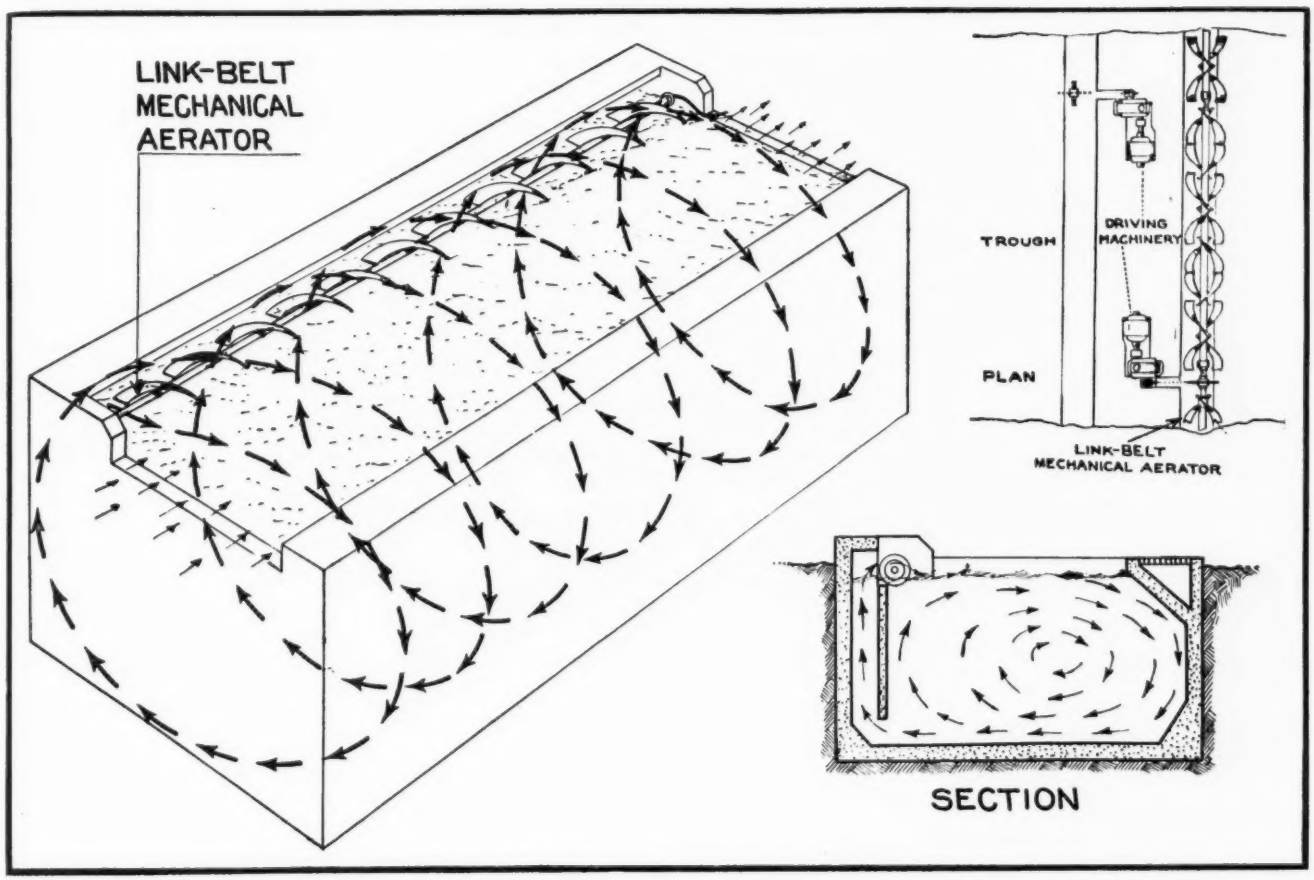
The Link-Belt Mechanical Aerator for Activated Sludge Plants

(PATENTED)



IMPARTS the spiral motion to the sewage shown on the schematic drawing above. With a 6 hour detention period, the B.O.D. of average domestic sewage is reduced approximately 90%. The power consumption per 1 M.G. is about 15 K.W.

Link-Belt collectors in final settling tanks are ideal for removing the settled sludge. Their speed is low, their action positive and the sludge is brought to the hopper in the shortest possible time.

Information on Link-Belt sewage treatment plant equipment — the Tark fine screen, the Brunotte coarse screen, sludge collectors and mechanical aerators sent on request.

LINK-BELT COMPANY

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LINK-BELT

SEWAGE TREATMENT PLANT EQUIPMENT

LEADITE

Trade Mark Registered U.S. Pat. Office

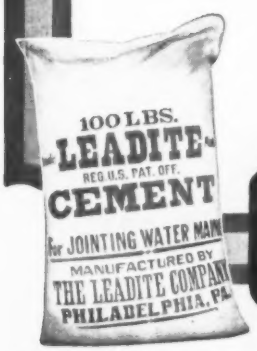
150 Miles of Water Mains Jointed with LEADITE

Washington Suburban Sanitary District, Hyattsville, Md. — of which Mr. R. B. Morse is the Chief Engineer, have laid more than 150 miles of cast iron water mains with LEADITE joints—sizes up to and including 24″—pressures up to 150 pounds per square inch. They use LEADITE exclusively for jointing their water mains—with excellent results.

Many years' experience has proven that on thousands of miles of water mains (of various sizes, and for various pressures) laid under all conditions,—LEADITE not only makes extremely tight joints, but withstands vibrations,—does not corrode or rust,—resists electrolysis,—eliminates caulking,—and reduces the cost of digging bell holes. In addition, the use of LEADITE "speeds up completion of the job, thus saving large sums in interest charges, and making the water line a revenue producer in a shorter time."

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 30 years.
Saves at least 75%

THE LEADITE COMPANY
Land Title Building - - - Philadelphia, Pa.



No Caulking

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Automatic "Cushioned" Controlling Altitude Valves

Cushion All Water Surges

Automatically maintains a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks. "Three Ways of Closing These Valves."

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. **Write for details.**

REMEMBER Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

Golden-Anderson Valve Specialty Co.

1385 Fulton Bldg., Pittsburgh, Pa.

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Float Valves

Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-in. to ¾-in. variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½ in. to 24 in.

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Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

GOLDEN-ANDERSON

Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.

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Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for Water Service.
2. For High or Low Pressure.
3. Thoroughly Cushioned. No Chattering, Hammering or Sticking.
4. Globe or Angle Patterns up to 24 in.
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Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipe, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves known.
4. No Metal-to-Metal Seats—No Water Hammer or Shock.
5. Cushioned by Air and Water.

Sizes ½" to 24".

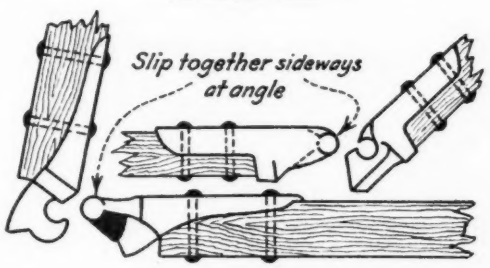
STEWART SEWER CLEANING MACHINE

Water Cleaning System, if you wish it, or Drag Bucket type.

WE WILL PAY FREIGHT AND CHARGE TO BILL.

We Ship Rods for Trial—who else will do this?

We also make a Rod that will float. Also Rods with wheels for conduit work.



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No Deep Shoulder Cut for Couplings. Rods retain full size and strength.

Investigate our JUMBO ROD

W. H. STEWART

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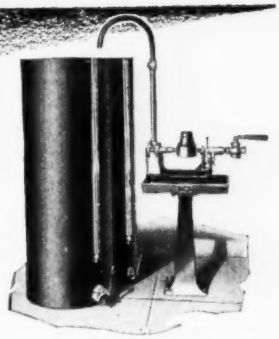
CANADA FACTORY, WALKERVILLE, ONT.
Therefore No Duty for Purchaser to Pay

PACIFIC COAST DELIVERIES MADE FROM SAN FRANCISCO

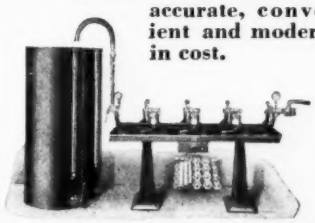
ONE.. OR A THOUSAND



WHATEVER your meter testing requirements are, Ford Testers handle the work economically and conveniently.

Standard testers take one, three, four or five meters at a time. We have built special testers for six, eight, ten and twelve meters in a series. Each meter is clamped in separately. Units can be adapted in a few seconds for ⅝", ¾", or 1" meters, and with special clamp will take 1¼", 1½" and 2" meters.

Ford Calibrated Tanks are accurate, convenient and moderate in cost.



A few Satisfied users of

Ford Series Testers

Chicago Water Department, —Four 5-unit and one 1-unit tester.
Philadelphia Water Dept. —Four 12-unit, two 10 unit and one 8-unit tester.
Indianapolis Water Co. —Two 5-unit testers.
Federal Water Service Corp. —Eight 5-unit, one 4-unit and two 1-unit.
Community Water Ser. Co. —Two 5-unit, and two 1-unit testers.
Cincinnati Water Dept. —One 4-unit tester.
Youngstown, O. Water Dept. —Two 5-unit testers.
University of Delaware —One 5-unit tester.

WATER METER SETTING & TESTING EQUIPMENT

The FORD METER BOX Co.

WABASH > INDIANA

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addesses furnished interested persons upon request.

New Lines Wanted

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Distributors of contractors' and builders' machinery and equipment are seeking line of road forms, road finishers, batcher plants, clamshell buckets and drag line buckets, for northern California terirtory. Now stocking equipment for several well known machinery manufacturers.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Road machinery distributor would like to secure exclusive sales rights for state of Mississippi for line of automatic or self-loading wheeled scraper.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Manufacturers' representatives located in New York would like to add line of heavy contractors' equipment of established reputation, other than the lines now handled by them. They would like exclusive sales rights for such equipment.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Machinery company in the east is interested in representing established lines of road machinery, with the exception of graders.

Distributor thoroughly familiar with bituminous materials and equipment for handling, wishes to add to present lines. Covers Wisconsin and Illinois territory.

Representatives Wanted

Manufacturer of truck, adapted to many uses, has attractive territory open in Missouri, Kentucky, Kansas, Nebraska and several southern states.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Manufacturer of excavating equipment desires to build up distribution organization throughout the country.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Manufacturer of two-cycle oil and gas engines, in sizes from 30 to 125 hp., adaptable for water works and many industrial purposes, wishes to establish points of distribution throughout the country.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

New York corporation wishes to establish agencies throughout the country, prefer men specializing in heating and ventilating equipment.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

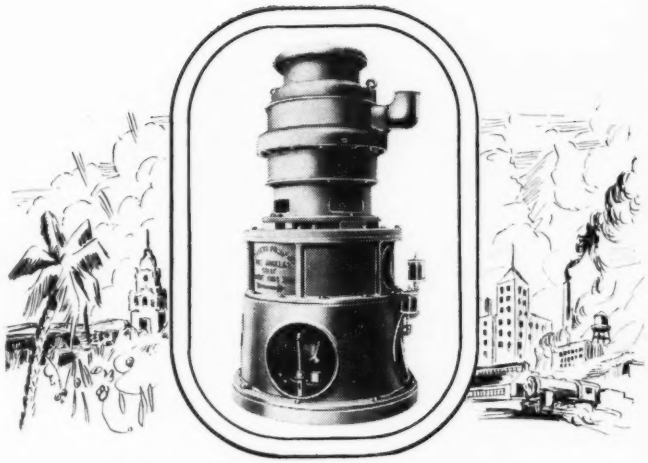
Manufacturer of automatic dipper trip, adapted to any type shovel (steam, gasoline, diesel, electric, etc.); with rapidly growing business, is seeking additional representatives.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Manufacturer of rotary pump, especially designed for road construction work, has proposition for reliable distribution houses.

Good side-line offered to manufacturers' representatives covering municipalities and public institutions.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.



The Choice of Cities

Dependable water supply being highly essential to municipalities, it is only natural that so many of the city engineers, who have thoroughly investigated the functions dependent upon efficient pumps, should specify PEERLESS to insure satisfactory service with the least maintenance expense.

Illustrated literature free upon request. No cost or obligation—just write Department W.

Peerless Pumps

YOU CAN ALWAYS DEPEND ON A PEERLESS—ALL WAYS

PEERLESS PUMP COMPANY

Executive Offices: 1902 E. 67th St., Los Angeles, Calif.

Factories: Los Angeles, Calif., Massillon, Ohio

New York Office: Room 513, 51 E. 42nd St. Massillon Office: 302 Walnut Avenue, S. W. Chicago Office. Room 410, 9 So. Clinton St

DISTRIBUTORS IN ALL PRINCIPAL CITIES

NORWOOD

Municipal Filtration Plants

are giving such satisfactory service wherever in service that water works officials considering such equipment will find that it pays to write us for complete information before placing their orders.

Write for Full Details

Norwood Engineering Company

Florence, Massachusetts

At Flankington plant

The North Sewage Screen

A clarifier which removes and aerates the effluent. Liquids go through perforations finer than a cambric needle.

Saves byproducts in a dry state.

Doubles capacity of old sewage plants. Decreases cost of new disposal plants.

Is all you need if effluent discharges into large streams.

The only *fine* screen on the market.

GREEN BAY FOUNDRY & MACHINE WORKS
GREEN BAY, WIS.

"NO VISIBLE SOLIDS IN EFFLUENT"

Bourbon

Fire Hydrants, Gate Valves and Extension Valve Boxes

Water Works and Fire Department Supplies

The Bourbon Copper and Brass Works Co.

618-620 E. Front St. Cincinnati, Ohio

USEFUL EQUIPMENT INFORMATION

Water Plants.—"Municipal Water Works" is the title of a booklet recently issued by the Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa. In addition to building storage tanks, this company is equipped to execute contracts for complete water works systems. The booklet describes various installations. Several useful tables are included.

Cement-Lined Pipe.—The Cement-Lined Pipe Co., Lynn, Mass., will be pleased to send "Cement-Lined Pipe for Corrosive Waters," a thorough discussion of the uses and advantages of water pipe lined with cement. Tables of weights and comparative costs are included.

Meters and Accessories.—The Pittsburg Equitable Meter Co., Pittsburgh, Pa., will be glad to send illustrated booklets covering meters, testing apparatus and various accessories for the meter department. The booklets contain drawings, specifications and tables of dimensions.

Refuse Disposal.—A valuable book for all who are concerned with the problem of refuse disposal is "Disposal of Municipal Refuse by Incineration." Whoever is planning or operating a disposal plant, municipal or private, should have this book. A copy may be secured from the Morse Boulger Destructor Co., 205 E. 42d St., New York, N. Y.

Moore Speedcrane.—The latest catalog of the Manitowoc Engineering Works, Manitowoc, Wis., describing the Moore "Speedcrane" shovel, dragline and trenchoe, presents a number of advanced features incorporated in this equipment. A copy may be secured by writing to the manufacturers.

Baker Bulldozers.—Bulletin No. 273 of the Baker Mfg. Co., Springfield, Ill., presents Baker hydraulic bulldozers for Caterpillar "30" and "60" tractors. A copy will be sent upon application.

Samplers and Mixers.—"Samplitt," a device by which samples of liquid are automatically secured from pipe lines as the liquid passes through the line, and "Mixitt," a device by which a small amount of one liquid is automatically injected into another in predetermined and adjustable percentages as the liquid requiring treatment flows through a pipe line, are described in bulletins issued by the Max B. Miller & Co., Inc., New York, N. Y. Tables for choosing sizes of these devices for various uses and conditions are included.

Rensselaer Valves.—The Rensselaer Valve Co., Troy, N. Y., will be pleased to send booklets and folders describing Rensselaer valves, tapping sleeves, crosses, repair sleeves, etc.

By writing the manufacturers named and mentioning this magazine, copies of the catalogs listed below will be sent you without obligation.

Copper Pipe Coupling.—A convenient booklet describing Anderson couplings for copper service pipe is issued by the Chapman Valve Mfg. Co., Indian Orchard, Mass. Specifications for copper service tubes are included.

Boilers.—The Erie City Iron Works, Erie, Pa., has recently issued two booklets, one of 16 pages covering the Erie City 3-drum boiler and one of 12 pages describing and illustrating the "Economic" boiler. A feature of the "Economic" booklet is a large phantom view with the principal points of construction indicated by arrows.

Diesel Engine Catalog.—An attractive 24-page catalog describing their new vertical diesel engine has been issued by the Buckeye Machine Co., of Lima, O. Copies are available to anyone interested.

Valves and Fittings.—The new Reading-Pratt & Cady catalog, No. 300, covers Pratt & Cady iron and bronze valves and asbestos-packed cocks, and Reading cast-steel valves and fittings. It includes much valuable information for the engineer, steamfitter and plumber. The catalog will be found a handy reference book for engineers, purchasing agents and anyone else interested in piping systems and valves and fittings. Copies may be secured by writing to the Reading Steel Casting Co., Inc., Bridgeport, Conn.

High-Temperature Cement.—"Firebond," a high-temperature cement, is described in a booklet recently issued by the Harbison-Walker Refractories Co., Pittsburgh, Pa. This booklet contains some new and useful tables for calculating the quantities of brick required for arches of different spans and thicknesses. These tables should be of interest to anyone connected with firebrick construction. The manufacturers will be pleased to send a copy to those interested.

Water Works Tools and Supplies.—Valves, hydrants, valve inserting machines, tapping machines, pipe cutters and other water works tools and supplies are described in a catalog of the A. P. Smith Mfg. Co., East Orange, N. J. Every water works superintendent should have a copy of this catalog.

For Recording Bids.—A convenience for contractors and officials alike is a bid record book, published by the United States Cast-Iron Pipe & Foundry Co., Burlington, N. J. It contains a table of standard thicknesses and weights of cast-iron pipe.

Federal Meters.—The latest Federal meters are presented in a bulletin of the Federal Meter Corp., East Orange, N. J. A copy will be sent upon application.

Incinerators.—A useful discussion of incineration, an account of the design and manufacture of "United States Standard" incinerators and a series of brief descriptions of installations of these incinerators are contained in a booklet issued by the Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa. Personal service in the matter of choice of a system of municipal refuse disposal is offered city officials by the Pittsburgh-Des Moines organization.

Venturi Meters.—Two booklets, "The Venturi Meter for Main Pipe Lines" and "Filtration Plant Equipment," have been issued by the Builders Iron Foundry, Providence, R. I. Valuable data for plant designers and all who are concerned with the measurement of flow in large pipe lines are contained within these bulletins. The type KS shunt meter, also manufactured by this foundry, is described in a leaflet which gives useful capacity tables.

Forced-Draft Fans.—The use of low grade, cheap fuels has been made possible in the last few years by the adoption of small forced-draft fans and special grates on domestic and other small furnaces and boilers. The American Blower Corp. has published a catalog showing standard forced-draft fans suitable for this use. The catalog also gives application and technical data of interest to any who contemplate installations of this kind. It is claimed that the use of the cheaper grades of fuel will pay for the necessary equipment in a very short time without loss of heating efficiency in the furnace. It is also claimed that the use of the forced-draft blower gives quicker "heating up" capacity and more flexible operation. The American Blower Corp., Detroit, Mich., will be glad to send a copy of their bulletin No. 10401 on this subject upon request.

Municipal Castings.—Clark municipal castings, service boxes, meter boxes and valve housings are described and illustrated in bulletins of the H. W. Clark Co., Mattoon, Ill. An inquiry will bring information on all Clark products.

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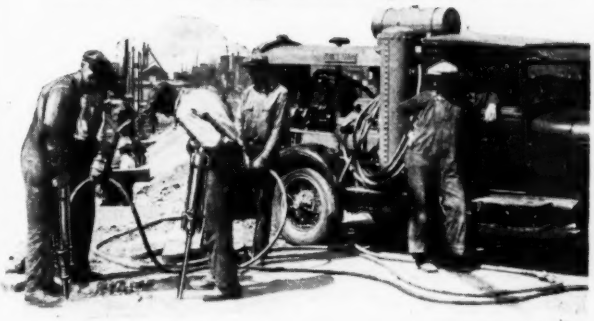

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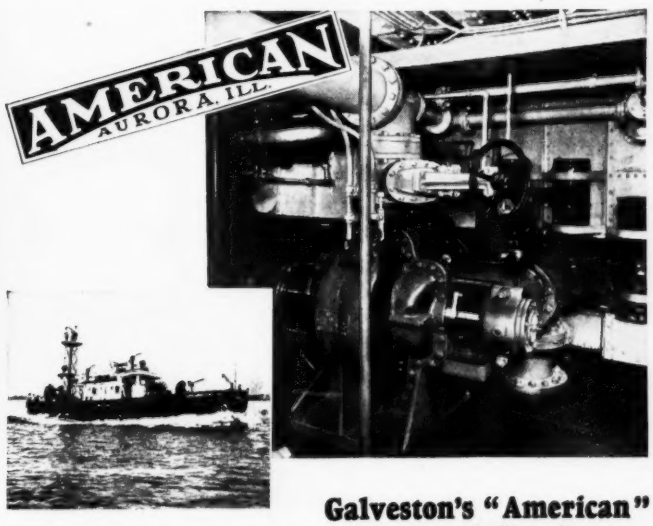

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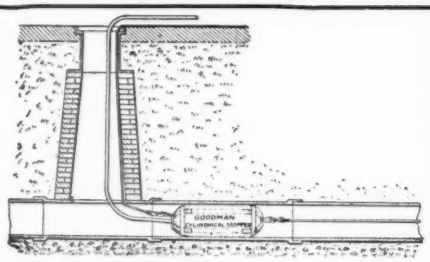

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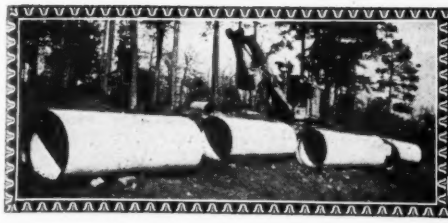

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2105 Hoists, Screw Chain
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2115 Hoppers, Aggregate Measuring
2120 Hose Clamps
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2130 Hose, Armored
2135 Hose, Gasoline
2140 Hose, Metallic, Flexible
2145 Hose, Oil
2155 Hose, Steam
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2167 Hydrants
2170 Hydrants, Fire
2175 Hydrants, Self-Closing
2180 Hydrants, Water
2185 Hydraulic, Measuring Instruments
2195 Hydraulic, Mining Nozzles
2196 Hydro Tite
2205 Indicator Posts
2210 Inlets, Curb
2215 Inserts, Steel
2220 Inspections & Tests
2245 Inundators
2250 Irons, Branding
2255 Iron Work, Ornamental
2260 Jacks, Lifting
2265 Jacks, Pumping Geared
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2340 Lighting Equipment, Industrial
2345 Lighting Plants, Contractors'
2350 Lights, Portable
2355 Limestone
2357 Lime
2360 Lime Hydrated
2365 Lintels
2375 Loaders
2380 Car & Wagon Loaders
2395 Loaders, Portable
2400 Loaders, Snow
2405 Loaders, Truck
2406 Lock Joint
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2440 Locomotives, Steam
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2470 Lumber, Creosoted
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2552 Meter Testers
2555 Meters, Jet
2560 Meters, Oil
2565 Meters, Pitot Tube
2570 Meters, Sewage (Venturi)
2575 Meters, Venturi
2580 Meters, Water
2590 Mixers, Concrete
2595 Mixers, Concrete Paving
2600 Mixers, Grout
2610 Mixers, Mortar
2616 Mortiser
2620 Motors, Air
2625 Motors, Centrifugal Pump
2630 Motors, Electric
2635 Motors, Gasoline
2640 Motor Truck Accessories (Cement Compartments, Scoopers, Truck Seats)
2645 Mountings, Truck Rubber Tires
2650 Movers, Car
2655 Oils, Road
2660 Oilers, Road (Pressure)
2665 Oilers, Rock Drill
2670 Oils, Building
2675 Oils, Creosote
2680 Oils, Road
2685 Ornaments, Architectural
2690 Paint, Asphalt
2695 Paints, Concrete
2700 Paint, Fire Retarding
2705 Paint, Industrial
2710 Paint, Traffic
2715 Painting, Compressed Air Equipment
2720 Paint, Sprayers
2725 Paints, Stains, Enamels, Varnishes & Finishes
2735 Partitions, Toilet
2740 Partition, Block (Gypsum)
2762 Patch, Cold
2770 Patch, Cold, Bituminous
2775 Patchers, Asphalt Surface
2780 Pavements, Bituminous
2785 Pavers
2790 Paving Blocks
2795 Paving Gauges
2800 Paving, Concrete
2805 Paving Guards, Steel
2806 Paving Materials, Vitrified Brick
2810 Paving Process, Speical
2815 Pens, Lettering
2817 Penstocks
2820 Picks & Shovels
2825 Pile Drivers
2826 Pile Drivers (Combination Locomotive Crane)
2830 Pile Hammers, Steam
2835 Piles, Creosoted
2840 Piles, Screw
2850 Piling, Sheet Steel
2865 Pipe, Cast Iron
2866 Pipe, Concrete
2875 Pipe, Conductor
2880 Pipe, Drain
2885 Pipe, Culvert
2890 Pipe, Dredge & Pontoon
2895 Pipe, Gas
2900 Pipe, Hydraulic
2910 Pipe, Lock Joint
2915 Pipe, Reinforced Concrete
2920 Pipe, Service
2925 Pipe, Sewer
2926 Pipe, Vitrified Clay
2927 Pipe, Water
2930 Pipe, Welded Iron
2935 Pipe, Well
2940 Pipe & Fittings, Cast Iron
2955 Pipe & Fittings, Steel
2965 Pipe & Fittings, Wood
2970 Pipe & Fittings, Wrought Iron
2975 Pipe Bending & Cutting Machines
2980 Pipe Cleaning
2990 Pipe Connections
2995 Pipe Covering, Asphalt
3000 Pipe, Drilling Machine
3010 Pipe, Jointing Materials
3015 Pipe Lines, Submerged
3030 Pipe Pushers
3040 Pipe Threading Machines
3045 Piping Industrial Plant
3060 Planers, Road
3065 Planers, Subgrade
3066 Areation Plants
3070 Plaster (Gypsum)
3085 Plates, Annealed
3090 Plates, Floor
3095 Plates, Joint
3100 Plates, Name
3105 Plates, Sheared
3110 Plate Work
3115 Plows, Grading
3130 Plows, Snow
3135 Plows, Spreader
3140 Plows, Unloading
3145 Plumbing Fixtures
3150 Plumbing Supplies
3155 Poles, Steel
3156 Portable Mill Drilling Machinery
3160 Post and Hole Machinery
3170 Posts, Fence
3175 Posts, Mile & Whistle
3180 Pots and Kettles, Metal Melting
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3245 Pumping Plants, Water Works
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3255 Pump Parts, Rod
3257 Pumps, All Sizes
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3265 Pumps, Air Lift
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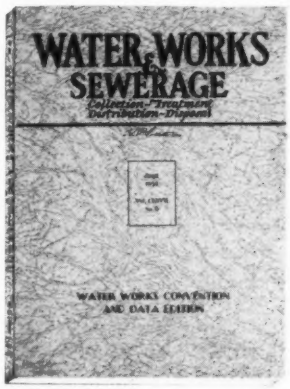

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